Major Shared Resource Center

ERDC MSRC

Programming Environment and Training Annual Report - Year Four

April 1999 - March 2000

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EXECUTIVE SUMMARY

The true deliverable of the ERDC MSRC PET effort is the raised level of ERDC MSRC user capability and programming environment in the ERDC MSRC – to a level not surpassed by academic, industry, or other government HPC centers. The ERDC MSRC PET team addresses this charge by providing core support to ERDC MSRC users, performing specific focused efforts designed to introduce new tools and computational technology into the ERDC MSRC, conducting training courses and workshops for ERDC MSRC users, and operating an HBCU/MI enhancement program.

The Programming Environment and Training (PET) component of the DoD HPC MSRCs is a bold and innovative university/industry/government effort to provide the essential user support and mode of capability enhancement that is necessary for the MSRCs to reach a level comparable to that in the foremost university, industry, and other Government agency HPC centers – and to address the wide variety of research and development demands arising from the science and technology programs supporting DoD's weapons development and warfighting support systems. The purpose of the PET component of the MSRCs is to enhance the entire programming environment for the MSRC users through training and support for software enhancement, addressing both near–term improvements and long–term expansions, thus enabling use of the MSRC computing resources to fullest capacity and extending the range of applicability of HPC to DoD technical problems.

The PET effort is unprecedented in its concept and vision, in its management for long–term achievement, in its strong university commitment, in its approach through unique university/DoD collaboration, in its understanding and relationship between university researchers and MSRC users – and in its challenge to be faced in the interest of DoD by the universities and companies involved, the MSRC users, and the program management. The PET component of the MSRC program is thus a true intellectual enterprise which breaks new ground in collaborative effort between DoD and academia in order to establish a two–way conduit of information and expertise enhancing the capability of the MSRC user and bringing demands of DoD HPC to bear early–on in programming environment developments in progress in the universities.

The ERDC MSRC PET effort is administered by the integrator, Computer Sciences Corporation (having acquired Nichols Research), for the ERDC MSRC as a part of the contract for the ERDC MSRC. Dr. Henry Gabb of CSC was the PET Director during Year 4, following Ray Burgess as interim. Dr. Joe Thompson of Mississippi State University is the ERDC MSRC PET academic team leader. Dr. Wayne Mastin of CSC, and a professor–emeritus of Mississippi State, is the on–site PET team leader. Dr. Willie Brown of Jackson State University is the HBCU/MI leader. Dr. Louis Turcotte of the ERDC MSRC exercised oversight of the ERDC MSRC PET effort for the government.

The fundamental mode of operation for PET at the ERDC MSRC is a direct and continual connection between the ERDC MSRC users and the ERDC MSRC PET team universities in support of the five Computational Technology Areas (CTAs) supported at the ERDC MSRC and three related technical infrastructure areas. This is accomplished through a combination of full–time university and CSC personnel on–site at the ERDC MSRC, in close communication with completely dedicated university personnel dividing time between the ERDC MSRC and the university, and with faculty members at the university with partial commitment to the ERDC MSRC PET effort for support and leadership.

The university PET team for the ERDC MSRC is led by the NSF Engineering Research Center for Computational Field Simulation at Mississippi State University, with Jackson State University as the lead HBCU/MI. The university team is as follows:

- Center for Computational Field Simulation
  (NSF Engineering Research Center at Mississippi State)
- National Center for Supercomputing Applications – NCSA
  (NSF PACI Center at Illinois)
- Northeast Parallel Architectures Center – NPAC
  (at Syracuse)
- Ohio State University & Ohio Supercomputer Center – OSC
  (at Ohio State)
- Texas Institute for Computational & Applied Mathematics – TICAM
  (at Texas)
- Rice University
- University of Tennessee
- University of Southern California
- HBCU/MIs: Jackson State University, Clark Atlanta University, and Texas A&M–Kingsville

Dedicated on–site/at–university support teams for each of the five DoD Computational Technology Areas (CTAs) supported at the ERDC MSRC were the responsibility of specific universities on the PET team at the ERDC MSRC in Year 4:

- CFD: Computational Fluid Dynamics – ERC (Mississippi State)
- CSM: Computational Structural Mechanics – TICAM (Texas) & ERC (Mississippi State)
- CWO: Climate/Weather/Ocean Modeling – Ohio State
- EQM: Environmental Quality Modeling – TICAM (Texas)
- FMS: Forces Modeling and Simulation/C4I – NPAC (Syracuse)

as was each of the technical infrastructure support areas:

- Scalable Parallel Programming Tools – Rice/Tennessee
- Scientific Visualization – NCSA (Illinois)
- Collaboration/Communication – NPAC (Syracuse)

Mississippi State, Texas, Ohio State and Rice maintain on–site university personnel at the ERDC MSRC in support of CFD (Dr. Steve Bova, now Dr. Nathan Prewitt – MSU), CSM (Dr. Rick Weed – MSU), EQM (Dr. Phu Luong – Texas) and Scalable Parallel Programming Tools (Dr. Clay Breshears – Rice), CWO (Dr. Steve Wornom – Ohio State). CSC also had a Training Coordinator (John Eberle–CSC).

Since the great majority of users of the ERDC MSRC are off–site, the PET effort at the ERDC MSRC places emphasis on outreach to remote users through visits to major remote user sites, training courses at such remote sites, web–based remote training delivery, and remote communication via email and the ERDC MSRC PET website. Central to this outreach to all users is an ERDC MSRC User Taxonomy that has been prepared and is maintained by the ERDC MSRC PET team in order to understand the user distribution and needs. During Year 4, the ERDC MSRC PET team was in direct contact with 79 ERDC MSRC users at seventeen sites. The ERDC MSRC PET team had 82 person–days in contact with MSRC users at the annual DoD HPC Users Group Meeting. In addition to the permanent on–site component of the ERDC MSRC PET team, other members from the team universities accumulated 157 of person–days on–site at ERDC MSRC.

Training is the most visible part of the PET program for many of the ERDC MSRC users. During Year 4, a total of twenty–one training courses were conducted, one of which was at a remote user site.

The Training and Education Facility (TEF) at ERDC MSRC is furnished with professional quality video production and recording equipment. Training material from any source (laptop, workstation, tranparencies, etc.) can be projected onto the classroom screen for instruction, broadcast over Mbone, and saved on videotape. Information on training courses is posted on the ERDC MSRC PET website:

http://www.wes.hpc.mil/

During Year 4, JSU and Syracuse University continued to present distance education courses over the Web. Syracuse delivered two graduate courses (Topics in Networking and Multimedia Applications; Advanced Web Technologies) to JSU and other sites, including Morgan State, Clark Atlanta, Mississippi State, and the ERDC MSRC. All offerings were full semester, for–credit courses delivered over the Web using the Tango collaborative software environment. The JSU/Syracuse communications link was implemented on the Defense Research and Engineering Network (DREN). This partnership between Jackson State and Syracuse has also served as a pilot for the use of the Tango and WebWisdom tools to deliver ERDC MSRC PET–sponsored training classes to DoD researchers.

The enhancement of the programming environment at ERDC MSRC through the identification and introduction of programming tools, computational tools, visualization tools, and collaboration/information tools is a major emphasis of the ERDC MSRC PET effort. Twelve such tools were introduced into ERDC MSRC, or updated, by the PET team during Year 4, and training courses at ERDC MSRC and at remote user sites for many of these tools were provided, along with continual guidance and assistance in their use through the on–site team at ERDC MSRC. Other tools introduced earlier are continually supported. The ERDC MSRC PET team conducted nineteen specific focused efforts during Year 4 in connection with this effort to evaluate, implement, and enhance such tools for introduction into the ERDC MSRC.

Assistance in migration of codes to the T3E, SP, and O2K was provided to ERDC MSRC users by the PET team both directly and by providing tools and technology to the ERDC MSRC Computational Migration Group at ERDC MSRC. The PET team also worked with ERDC MSRC users to enhance algorithms, physics, and visualization in user codes in the CTA areas supported at ERDC MSRC, with specific impact on twenty–one ERDC MSRC user codes during Year 4.

During Year 4, the ERDC MSRC PET team included 99 people from 11 universities, 38 of whom are PhDs. There were 27 person–days of travel to remote user sites, and 36 person–days at HBCUs. There were also 90 person–days of travel to national meetings for presentations related to the ERDC MSRC PET effort, to meet ERDC MSRC users and to track technology developments in the interest of the ERDC MSRC PET effort.

A total of 21 training courses covering 39 days, were conducted on–site at ERDC MSRC, and one course covering four days was conducted at a remote user site. These on–site training courses were attended by 188, and the off–site course was attended by eight. A summer institute was conducted, at Jackson State, impacting students from nine HBCUs. Three seminars were conducted at Jackson

State, Clark Atlanta, and Morgan State. Three regular semester courses were conducted at Jackson State, Clark Atlanta, and Morgan State, over the web. The ERDC MSRC PET team produced 30 ERDC MSRC/PET technical reports, 50 conference presentations, 6 book chapters, and 16 journal papers reporting on efforts of Year 4.

1. Introduction

1.1 The DoD High Performance Computing (HPC) Modernization Program (HPCMP)

The Department of Defense (DoD) High Performance Computing (HPC) Modernization Program (HPCMP) was instituted in 1994 to modernize the total high performance computational capability of the military research, development, test, and evaluation (RDT&E) community to a level comparable to that available in the foremost civilian and other government agency RDT&E communities. A key component of this initiative is the DoD Major Shared Resource Centers (MSRCs).

The MSRCs provide complete HPC environments and include various types of computing systems, scientific visualization capabilities, extensive peripheral and archival storage, and expertise in use of these systems. The MSRCs support the wide variety of research and development problems arising from the science and technology programs supporting DoD's weapons development and warfighting support systems. The MSRCs provide the computer and computational sciences expertise to allow all of the DoD laboratories to advance their capability in science and technology. The types of computer systems in the MSRCs are determined by user requirements and differ from one MSRC to another.

The HPCMP selected four DoD sites to become MSRCs:

- Army Engineer Research and Development Center (ERDC), Vicksburg MS
- Army Research Laboratory (ARL), Aberdeen Proving Grounds MD
- Naval Oceanographic Office (NAVO), Stennis Space Center MS
- Air Force Aeronautical Systems Center (ASC), Wright–Patterson AFB, OH

In addition, DoD has identified ten Computational Technology Areas (CTAs) as being critical across all of DoD. These ten CTAs supported by the HPCMP are:

- CFD: Computational Fluid Dynamics
- CSM: Computational Structural Mechanics
- CCM: Computational Chemistry and Materials Science
- CEA: Computational Electromagnetics and Acoustics
- CWO: Climate/Weather/Ocean Modeling
- SIP: Signal/Image Processing
- FMS: Forces Modeling and Simulation/C4I
- EQM: Environmental Quality Modeling
- CEN: Computational Electronics and Nano–Electronics
- IMT: Integrated Modeling and Testing

An integral part of the DoD HPCMP is the provision of Programming Environment and Training (PET) at each of the MSRCs by university/industry teams in order to enable DoD researchers to develop and utilize the necessary HPC software. The PET program includes training courses in all aspects of HPC in the Computational Technology Areas (CTAs) and in relevant programming and technical infrastructure areas. And it includes side–by–side transitioning of research codes into the MSRCs, as well as collaboration with MSRC users to advance and improve those codes.

The DoD HPCMP and the MSRCs are described more fully at the HPCMO website:

http://www.hpcmo.hpc.mil/

1.2 The Programming Environment and Training (PET) Program

The Programming Environment and Training (PET) component of the DoD HPC MSRCs is a bold and innovative approach to enhancing the capability of the MSRC users comensurate with the enhancement of the power of the hardware in the MSRCs, in order to realize the expressly stated goal of the DoD HPC Modernization Program to attain a level comparable to that in the foremost university, industry, and other government agency HPC centers. The PET effort provides the essential user support and mode of capability enhancement that is necessary for the MSRCs to attain this goal – and to address the wide variety of research and development demands arising from the science and technology programs supporting DoD's weapons development and warfighting support systems.

The purpose of the PET component of the MSRCs is to enhance the entire programming environment for the MSRC users through training and support for software enhancement, addressing both near–term improvements and long–term expansions, thus enabling use of the MSRC computing resources to fullest capacity and extending the range of applicability of HPC to DoD technical problems.

The PET component of the MSRC program is thus a true intellectual enterprise which breaks new ground in collaborative effort between DoD and academia in order to establish a two–way conduit of information and expertise enhancing the capability of the MSRC user and bringing demands of DoD HPC to bear early–on in programming environment developments in progress in the universities. The PET effort is unprecedented in its concept and vision, in its management for long–term achievement, in its strong university commitment, in its approach through unique university/DoD collaboration, in its understanding and relationship between university researchers and MSRC users – and in its challenge posed in the interest of DoD to the universities and companies involved, the MSRC users, and the program management.

The PET team at the ERDC MSRC has now completed its fourth year of effort, and that is the subject of this report. The approach of this report is to collect complete data and item lists on all aspects of the Year 4 PET effort of the ERDC MSRC into a series of tables, so that the text can concentrate on a narrative of the operation and accomplishments of the effort. More complete and continually updated information on the current PET effort of the ERDC MSRC is accessible on the ERDC MSRC PET website which is reachable from the ERDC MSRC website:

http://www.wes.hpc.mil/

After discussing the strategic plan for the ERDC MSRC PET effort and its general implementation in Sections 2 and 3, the specific organization of the ERDC MSRC PET support structure is described in Section 4. Major accomplishments of the PET effort at ERDC MSRC during Year 4 are presented in Section 5. Of particular impact are the tools introduced into the ERDC MSRC covered in Section 6. The training component of the ERDC MSRC PET effort is a major means of transfering technology to ERDC MSRC users, and this component is reported in Section 7. Further specific discussion of outreach to ERDC MSRC users, both on–site and remote, appears in Section 8. The HBCU/MI element of the ERDC MSRC PET effort in Section 9 is especially important in that it serves to enhance the capability of HBCU/MIs in high performance computing and in the ability of these institutions to produce future researchers in this area. Finally, a complete list of publications arising from the PET effort at the ERDC MSRC is included.

2. ERDC MSRC PET Strategic Plan

The strategic plan of the ERDC MSRC PET effort has evolved over the first two years of operation, through close collaboration of the university team leadership with that of Computer Sciences Corporation and the ERDC MSRC.

2.1 Goals and Objectives

The goal of the PET effort at the ERDC MSRC is to bring university HPC knowledge and skills to bear on both the overall theme, scalable HPC applications and performance, and the specific sub–areas applicable to the ERDC MSRC: scalable computing migration, HPC training and DoD user productivity, HPC performance metrics tools, management and interpretation of large data sets, SciVis for very large problems, and DoD challenge applications.

The key objectives of the PET effort in the ERDC MSRC are as follows:

- Establish a mechanism for identifying and transfering emerging advances in programming environments, computational tools, algorithms, and computational solution techniques for CTA applications from academia and industry into the ERDC MSRC.
- Create a virtual extension of the ERDC MSRC into academia that will be responsible for identifying and acquiring near–term programming environment improvements and long–term expansions, anticipating ERDC MSRC user needs and making users aware of pertinent emerging technology.
- Utilize state–of–the–art HPC technology as an inherent part of the implementation of the ERDC MSRC PET Program itself.
- Establish a training program to ensure ERDC MSRC user proficiency with transfered advances in HPC tools and technology.
- Establish cooperative development and training programs with HBCUs/MIs to significantly enhance participation in the HPC community.
- Establish effective collaboration with academia to encourage the development of graduate and post–doc programs that will enhance the skill levels and efficiency of the DoD HPC community.

Based on this, the vision for PET at ERDC MSRC is to:

- Transfer cutting edge, innovative HPC technology and tools from premier university centers to ERDC MSRC users and laboratories.
- Provide innovative collaborative environments for HPC research to all ERDC MSRC users (“remove importance of place”).
- Train ERDC MSRC users in state–of–the–art HPC and scalable parallel processing (SPPT) programming tools and techniques.
- Use HBCU/MI partners in an integral way to support PET objectives, enhance faculty and train minority students in HPC.
- Enable ERDC MSRC to make major productivity gains from current/planned hardware acquisitions in PL1/2/3.

The true deliverable of the ERDC MSRC PET effort is the raised level of ERDC MSRC user capability and programming environment in the ERDC MSRC – to a level not surpassed by academic, industry, or other government HPC centers.

2.2 Approach

The approach to PET at the ERDC MSRC is to marshall an elite and readily accessible university team to constitute a virtual extension of the ERDC MSRC into top academic expertise, able both to respond and anticipate needs of the ERDC MSRC users for training and assistive collaboration in advancing the programming environment, utilizing a combination of strong on–site presence and dedicated support from the universities.

Support for ERDC MSRC users is provided by the PET team in the five Computational Technology Areas (CTAs) for which the ERDC MSRC has responsibility:

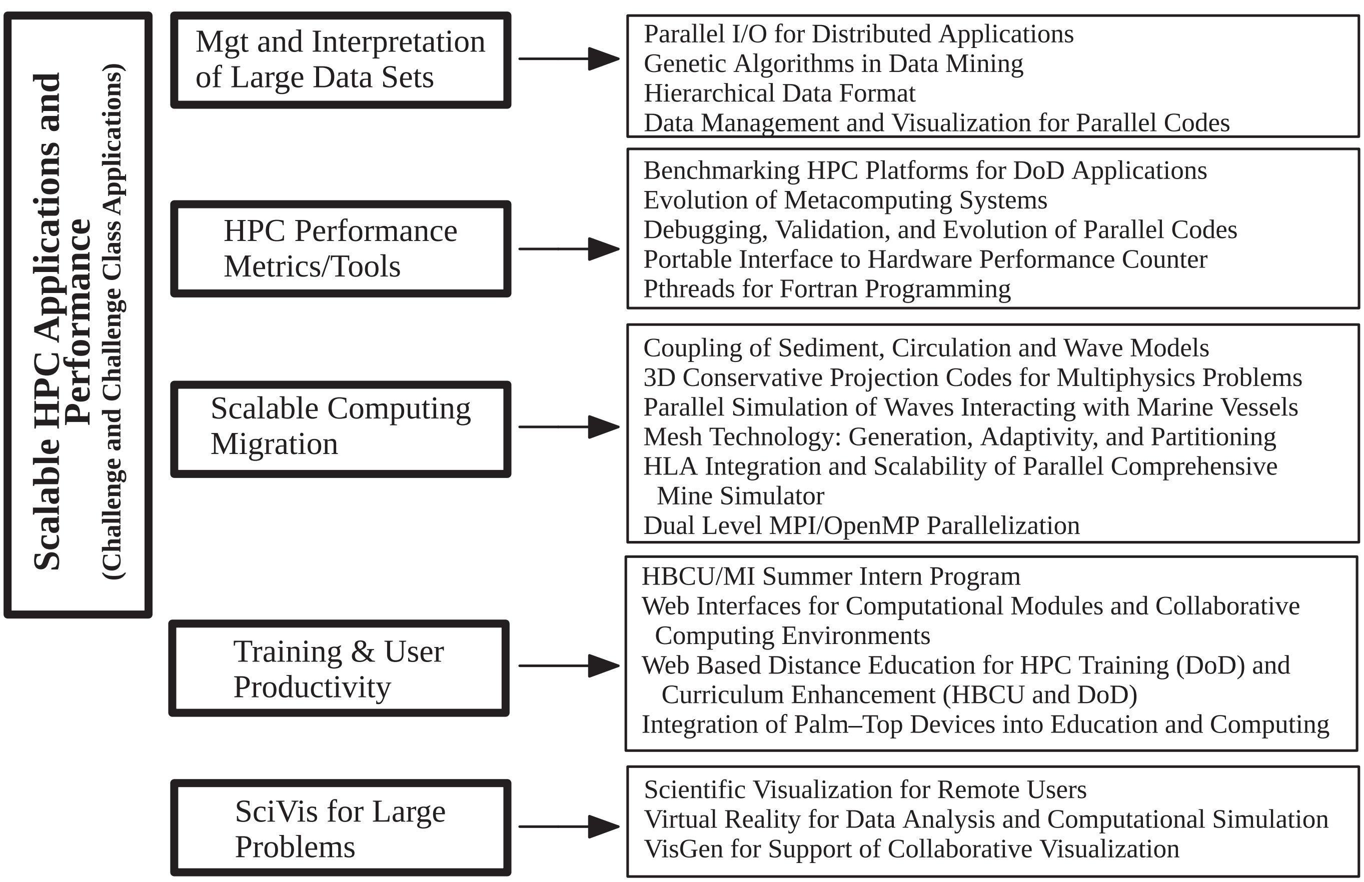
- CFD: Computational Fluid Dynamics
- CSM: Computational Structural Mechanics
- CWO: Climate/Weather/Ocean Modeling
- EQM: Environmental Quality Modeling
- FMS: Forces Modeling and Simulation/C4I

and also for three relevant technical infrastructure areas:

- Scalable Parallel Programming Tools
- Scientific Visualization
- Collaboration/Communication

The PET effort at ERDC MSRC consists of three fundamental elements: Core Support, Focused Efforts, and Training. Intertwined with these efforts are outreach to ERDC MSRC users and a program to enhance the involvement of HBCU/MIs in HPC.

ERDC MSRC Thematic Area



Core Support provides continual interaction and assistive collaboration with ERDC MSRC users in the technical areas supported at the ERDC MSRC to migrate and enhance important codes to scalable parallel platforms and to extend the applicability of such codes and systems.

Focused Efforts address current specific projects to enhance the programming environment at the ERDC MSRC and the capabilities of ERDC MSRC users.

Training provides instruction for MSRC users, both on–site at ERDC MSRC and remote, in the technical areas supported at the ERDC MSRC and consists of both in–person and web–based courses.

2.3 Core Support

Core Support is provided to the ERDC MSRC through continual interaction in each of five CTAs supported at the ERDC MSRC, as well as in the three technical support areas, with a specific supporting university on the PET team having responsibility for each area.

This Core Support operates primarily on–site at the ERDC MSRC, coupled with continual support from specific individuals at the university, through continual interaction and assistive collaboration of the PET team with ERDC MSRC users in the five CTAs supported at the ERDC MSRC, and in the three technical support areas, to migrate important codes to scalable parallel platforms and to enhance and extend the applicability of such codes and systems. In the operation of this Core Support, ERDC MSRC user demographics and software usage are continually monitored to provide input for identification of codes and systems of important impact.

2.4 Focused Efforts

In addition to this continual Core Support, certain specific Focused Efforts within the scope of the ERDC MSRC and the resources of the PET effort are identified for implementation by the ERDC MSRC PET team, operating across the universities as necessary. Such projects have specific objectives and deliverables. When appropriate, projects involve coordinated efforts among PET teams from other MSRCs and/or funding from other MSRC PET efforts. Interest by ERDC MSRC users in collaborative effort in such projects is a necessary factor in identification of such Focused Efforts for implementation.

2.5 Training

Training is conducted with emphasis on intermediate and advanced topics, and is coordinated across the MSRCs to reach the entire DoD user community. A state–of–the–art training facility is maintained at the ERDC MSRC with workstations for hands–on training and facilities for remote transmission. Delivery is on–site at the ERDC MSRC, in–person at some other DoD sites and at the universities as appropriate, and remotely using emerging distance learning approaches. Training specifically addresses the need to reach an ever greater number of DoD users, leveraging emerging digital infrastructures and the unique educational expertise of the ERDC MSRC PET team. Delivery is ultimately to be any time, any place, and at any pace.

2.6 Outreach

Since the great majority of users of the ERDC MSRC are off–site, the PET effort at the ERDC MSRC places emphasis on outreach to remote users through visits to major remote user sites, training courses at such remote sites, web–based remote training delivery, and remote communication via email and the ERDC MSRC PET website. Emphasis is also placed on the implementation of appropriate tools for remote collaboration, especially with regard to scientific visualization. Continually updated user demographics are assembled into an ERDC MSRC user taxonomy to guide this outreach to all users of the ERDC MSRC.

2.7 HBCU/MI Program

The principal purpose of the HBCU/MI component of the PET effort at the ERDC MSRC is to enhance the capability of the HBCU/MI members of the ERDC MSRC PET academic team to participate fully in the PET support effort of the ERDC MSRC. To this end, both Jackson State and Clark Atlanta are involved directly in Focused Efforts. Particular emphasis is placed on enhancing the opportunities of students at the HBCU/MI PET partners through web–based university classes at the HBCU/MIs from the other PET team members and through summer institutes at the HBCU/MIs.

3. Implementation

3.1 Management

The ERDC MSRC PET effort is administered by the integrator, Computer Sciences Corporation (CSC), for the ERDC MSRC as a part of the ERDC MSRC contract. Dr. Henry Gabb of CSC is the PET Director. Dr. Joe Thompson of Mississippi State University is ERDC MSRC PET academic team leader. Dr. Wayne Mastin of CSC, and a professor emeritus of Mississippi State, is the on–site PET team leader. Dr. Willie Brown of Jackson State University is the HBCU/MI leader. Dr. Louis Turcotte of the ERDC MSRC exercises oversight of the ERDC MSRC PET effort for the government.

3.2 Organization

The fundamental mode of operation for PET at the ERDC MSRC is a direct and continual connection between the ERDC MSRC users and the ERDC MSRC PET team universities in support of the five Computational Technology Areas (CTAs) supported at the ERDC MSRC and three related technical infrastructure areas. This is accomplished through a combination of full–time university and CSC personnel on–site at the ERDC MSRC, in close communication with completely dedicated university personnel dividing time between the ERDC MSRC and the university, and faculty members at the university with partial commitment to the ERDC MSRC PET effort for support and leadership.

3.3 Team Composition

The university PET team for the ERDC MSRC is led by the NSF Engineering Research Center for Computational Field Simulation at Mississippi State University, with Jackson State University as the lead HBCU/MI. The university team is as follows:

- Center for Computational Field Simulation
  (NSF Engineering Research Center at Mississippi State)
- National Center for Supercomputing Applications – NCSA
  (NSF PACI Center at Illinois)
- Northeast Parallel Architectures Center – NPAC
  (at Syracuse)
- Ohio State University & Ohio Supercomputer Center – OSC
  (at Ohio State)
- Texas Institute for Computational & Applied Mathematics – TICAM
  (at Texas)
- Rice University
- University of Tennessee
- University of Southern California
- HBCU/MIs: Jackson State University, Clark Atlanta University, and Texas A&M–Kingsville

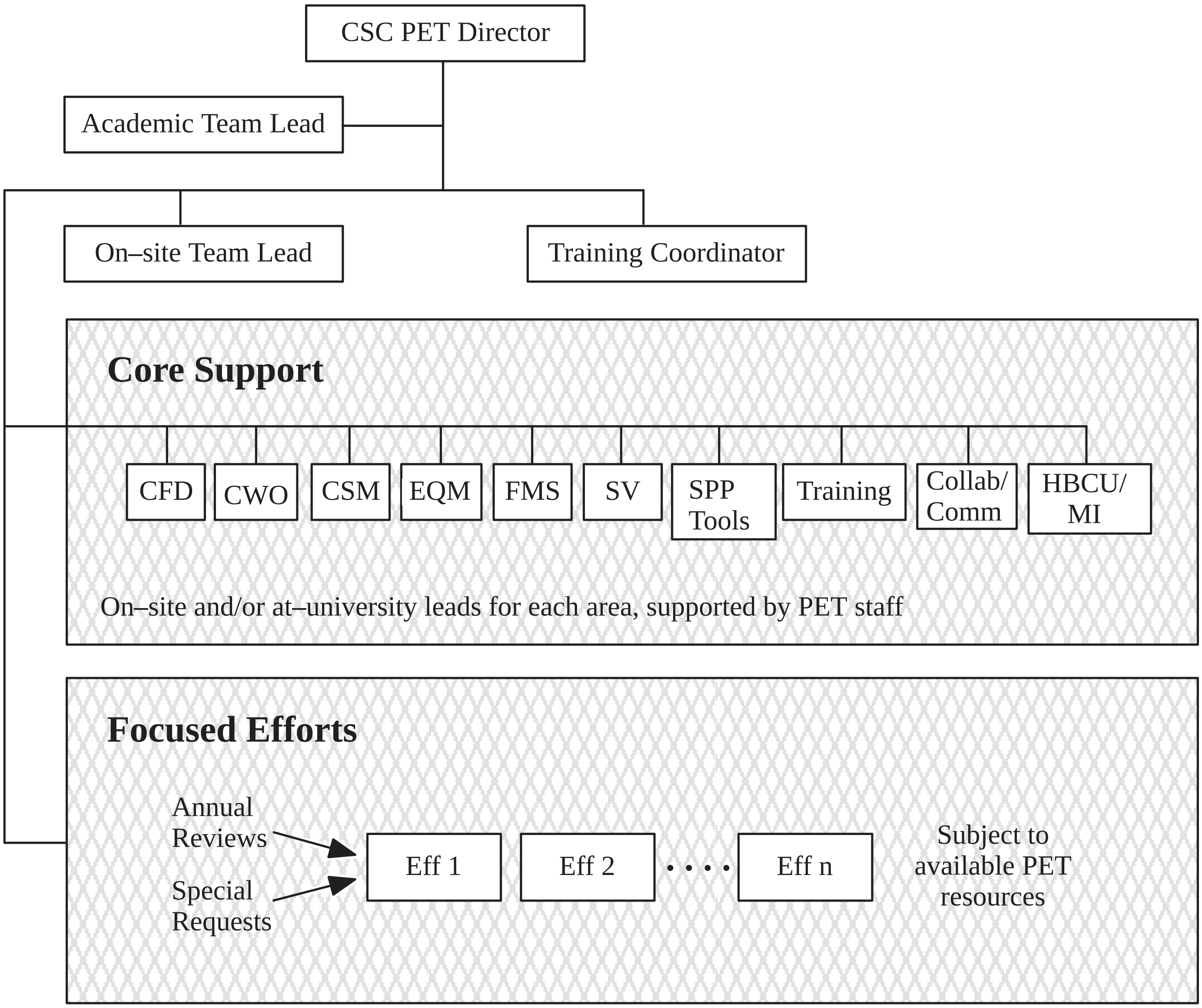
Dedicated on–site/at–university support teams for each of the five DoD Computational Technology Areas (CTAs) supported at the ERDC MSRC were the responsibility of specific universities on the PET team at the ERDC MSRC in Year 4:

- CFD: Computational Fluid Dynamics – ERC (Mississippi State)
- CSM: Computational Structural Mechanics – TICAM (Texas) &
  ERC (Mississippi State)

- CWO: Climate/Weather/Ocean Modeling – OSU (Ohio State)
- EQM: Environmental Quality Modeling – TICAM (Texas)
- FMS: Forces Modeling and Simulation/C4I – NPAC (Syracuse)

as also was each of the technical support areas:

- Scalable Parallel Programming Tools – Rice/Tennessee
- Scientific Visualization – NCSA (Illinois)
- Collaboration/Communication – NPAC (Syracuse)



PET Organizational Structure

Mississippi State, Texas, Ohio State, and Rice maintain on–site university personnel at the ERDC MSRC in support of CFD (Dr. Steve Bova, now Dr. Nathan Prewitt – MSU), CSM (Dr. Rick Weed – MSU), EQM (Dr. Phu Luong – Texas), CWO (Dr. Stephen Wornom – Ohio State) and Scalable

Parallel Programming Tools (Dr. Clay Breshears – Rice). CSC also has a Training Coordinator (John Eberle – CSC) on–site.

3.4 Reporting and Technology Transfer

Transfer of emerging technology from the academic community into the ERDC MSRC is a primary purpose of the ERDC MSRC PET effort. Of like importance is transfer in the other direction, providing input and feedback regarding emerging DoD needs to influence developments at universities. The primary mode of technology transfer in the ERDC MSRC PET effort is direct contact between the PET team and the ERDC MSRC users. But the PET team also produces a series of reports on technology developments for distribution to ERDC MSRC users. And technology transfer is a prime emphasis of the training component of the ERDC MSRC PET effort. The on–site personnel at the ERDC MSRC from the PET team form a continual conduit for technology transfer.

4. Technical Support Teams

The fundamental mode of operation for the PET support effort at the ERDC MSRC is a direct and continual connection between the ERDC MSRC PET team universities and the ERDC MSRC users in support of the five Computational Technology Areas (CTAs) supported at the ERDC MSRC and three related technical infrastructure areas.

This is accomplished through on–site PET team members at the ERDC MSRC in close communication with PET team members at the supporting universities, who also make frequent visits to ERDC MSRC. The PET team members on–site at ERDC MSRC are full–time university personnel, supplemented by CSC personnel. The on–site PET team members at the ERDC MSRC are key to the ERDC MSRC PET operation, since these team members are the front line of contact with ERDC MSRC users.

These six on–site team members are:

- Lead: Dr. Wayne Mastin – CSC (Professor Emeritus, Mississippi State)
- CFD: Dr. Steve Bova, then Dr Nathan Prewitt – Mississippi State
- CSM: Dr. Rick Weed – Mississippi State
- CWO: Dr. Steve Wornom – Ohio State
- EQM: Dr. Phu Luong – Texas
- SPPT: Dr. Clay Breshears – Rice

Also on–site at ERDC MSRC are the overall PET Project Leader – Ray Burgess as interim, then Dr. Henry Gabb – and the Training Coordinator, John Eberle, all of CSC. A complete listing of all the ERDC MSRC PET team personnel is given in Table 1.

During Year 4, the eight technical support teams in the ERDC MSRC PET effort operated as follows:

4.1 CFD: Computational Fluid Dynamics CTA (ERC – Mississippi State)

As part of the PET effort at the ERDC MSRC, CFD support is the responsibility of the NSF Engineering Research Center for Computational Field Simulation at Mississippi State University. During the fourth contract year, Senior Academic leadership was changed: effective June 1, 1999, Dr. Bharat Soni assumed the Senior Academic lead position. Dr. Steve Bova , the On–Site CFD Lead accepted a position with Sandia National Laboratory effective August 1, 1999. Dr. Nathan Prewitt assumed the On–Site Lead position effective February 1, 2000. During this year, the CFD support team consisted of Dr. David Huddleston (Senior Academic Lead – until May 31, 1999), Dr. Bharat Soni (Senior Academic Lead – from June 1, 1999), Dr. Steve Bova (On–Site Lead, until July 31, 1999), and Dr. Nathan Prewitt (On–Site Lead, from February 1, 2000). The On–Site Lead (Bova/Prewitt) serves as an effective administrative liaison among the ERDC MSRC, CSC, and MSU, and as a technical liaison between ERDC MSRC users and the entire CFD support team. The On–Site Lead also coordinates communication and facilitates interaction with other components of the ERDC MSRC PET team. This includes maintenance of the CFD web–page content and bi–weekly activity reporting.

The CFD team in the ERDC MSRC PET effort serves the ERDC MSRC by providing:

- Program–wide CFD support.
- R & D expertise on selected technology enhancements.
- HPC assistance for targeted codes.

Program–wide support includes direct ERDC MSRC user contact and cultivation, participation in workshops and technical meetings, user training in HPC, and other generic duties. HPC support for targeted codes and delivery of collaborative R&D expertise are more specific tasks selected to provide technology that has potential application and interest throughout the ERDC MSRC user community. Because of the absence of an On–Site Lead from July 1, 1999 to January 31, 2000, the Senior Academic Lead assumed responsibility for user contact and interaction during that period. Also, only core support was provided during Year 4. No activity in the area of Focused Effort was conducted.

4.2 CSM: Computational Structural Mechanics CTA (TICAM – Texas, with ERC – Mississippi State)

The team is led by J. Tinsley Oden (TICAM Director) and Graham F. Carey (TICAM, Texas) as Co–Principal Investigators. David Littlefield (IAT–Texas) is a major research contributor and works closely with the CTH application group (G. Hertel, D. Crawford) at Sandia. Abani Patra (University of Buffalo) and Atanas Pehlivanov (Texas) have been conducting studies related to EPIC. Robert McLay is working with David Littlefield on the design of a software testbed to evaluate indicators and algorithms for incorporation in CTH. Serge Prudhomme is collaborating on the residual indicator work and on the Testbed simulation tests. Tinsley Oden and Graham Carey are also carrying out research (with the team members) on error indicators and adaptive strategies to support the effort.

Dr. Richard Weed (Mississippi State) serves as the On–Site CSM Lead at the ERDC MSRC. As On–Site Lead, Dr. Weed's duties encompass a wide range of direct support activities for ERDC MSRC users. These duties include conducting training classes in Parallel Programming methods, programming support for on–going HPCMP Challenge projects and CHSSI code projects, and programmatic support for TICAM Core Support and Focused Effort activities.

4.3 CWO: Climate/Weather/Ocean Modeling CTA (Ohio State)

The Ohio State University (OSU) CWO team is led by Professor Keith Bedford, Chair of the Department of Civil and Environmental Engineering and Geodetic Science (CEEGS). Senior leadership is also provided by Professor Ponnuswamy Sadayappan of the Department of Computer and Information Science (CIS). OSU CEEGS staff members Drs. Stephen Wornom and David Welsh serve as CWO On–Site Lead and Research Scientist, respectively. CIS graduate student Rong Wang completes the OSU team.

The OSU CWO team coordinate their activities by means of weekly group meetings, with Dr. Wornom participating via speaker–phone. Dr. Wornom also travels to OSU during the preparations for mid–year and annual project reviews.

Professors Bedford and Sadayappan are responsible for project management, technical guidance, the preparation and review of training class materials, and management–level contacts with MSRC users and other CTA leaders. The OSU group arranges major planning meetings with MSRC users to coincide with the on–site visits of Drs. Bedford and Sadayappan. Prof. Bedford is the technical lead regarding the physics content of PET CWO efforts, while Prof. Sadayappan is technical lead for matters concerning computational performance and code–parallelization.

Dr. Wornom is primarily reponsible for day–to–day contact with and outreach to MSRC users. He is responsible for the planning of CWO training classes and has also arranged OSU team visits to present/discuss CWO research with off–site ERDC MSRC users and other DoD CWO scientists. Dr. Wornom pays particular attention to maintaining a high level of visibility for the OSU team, so that users will be aware of PET research and resources.

Dr. Welsh is responsible for the implementation of physics upgrades, including model–coupling, in CWO numerical models. He also contributes to code–parallelization efforts. Dr. Welsh has taken a lead role in the reporting of CWO activities in terms of training class and seminar presentations and the preparation of reports and proposals. Dr. Welsh has a background in wave modeling and has, therefore, taken responsibility for detailed technical interaction with the ERDC CHL wave modeling group.

Rong Wang, under the guidance of Prof. Sadayappan, is responsible for the performance optimization and parallelization of CWO codes. He has also aided Dr. Welsh in the coding of the communication operations in coupled model systems.

4.4 EQM: Environmental Quality Modeling CTA (TICAM – Texas)

The PET Team for EQM includes Drs. Mary F. Wheeler (University Lead), Clint Dawson, Phu Luong (On–site Lead), Victor Parr and Jichun Li and graduate students Jennifer Proft, Sharon Lozano, and Dharhas Potina. Wheeler and Dawson provide technical leadership and assistance in numerical analysis and computational science as well as teaching tutorials and holding workshops. Luong's efforts are devoted to attending training classes, making contacts with ERDC MSRC EQM users, organizing workshops in conjunction with Texas personnel, and working on specific codes with Drs. Henry Gabb and Clay Breshears. Wheeler, Dawson, and Luong are also involved in collaborations in developing conference posters, conference papers and journal papers. Parr's activities center around debugging, validation, and evaluation of several EQM codes as well as working with Li on the grid projection code development. Proft and Lozano taught a tutorial at Jackson State, and Potina was involved in replacement of a solver in CH3D during Year 4.

4.5 FMS: Forces Modeling and Simulation/C4I CTA (NPAC – Syracuse)

The PET FMS support team is based at the Northeast Parallel Architectures Center (NPAC) at Syracuse University. Within NPAC, FMS activities are centered around the Interactive Web Technologies (IWT) group, lead by Dr. Wojtek Furmanski. The group includes two research scientists and roughly a dozen graduate research assistants who make various contributions to FMS activities.

4.6 C/C: Collaboration and Communications (NPAC – Syracuse)

The Northeast Parallel Architectures Center (NPAC) at Syracuse University provides the team that supports the Collaboration and Communications and closely related Training technology areas. The Syracuse team is lead by NPAC's Director, Prof. Geoffrey C. Fox, and draws as necessary on the wide range of C/C–related capabilities represented by the Center's research staff and students. Principal contributions to the support effort during Year 4 came from Dr. David Bernholdt, the Tango Interactive Collaboratory Group headed by Dr. Marek Podgorny, and Dr. Tom Haupt in the area of commodity–based distributed high–performance computing. The NPAC team focuses on tracking, developing, and adapting the latest technologies and ideas for use in the Modernization Program, while day–to–day C/C operations, such as the PET website and the Tango Interactive server are handled by CSC on–site staff.

4.7 SPP Tools: Scalable Parallel Programming Tools (Rice and Tennessee)

4.7.1 Rice

Dr. Clay P. Breshears is the On–Site PET SPP Tools Lead at the ERDC MSRC and deals with day–by–day contacts, tool installation and use, and other duties as required. Dr. Richard J. Hanson at Rice University in Houston, TX concentrates on focused efforts, training, reporting, and support of certain ERDC MSRC code packages.

4.7.2 Tennessee

The Tennessee PET team is drawn from researchers and graduate students who make up the Innovative Computing Laboratory (ICL), a research group of over forty people under the direction of Distinguished Professor Jack Dongarra at the University of Tennessee–Knoxville. ICL has internationally recognized expertise in the areas of parallel linear algebra and high performance math software, parallel and distributed inter–process communication, and performance evaluation and optimization.

ICL has produced the widely used high–quality LAPACK and ScaLAPACK linear algebra libraries, as well as the PVM and NetSolve parallel computing systems. Several of the ICL research staff spend a significant portion of their time working on ERDC MSRC PET projects and core support activities. In addition, any of the ICL staff are available for short–term consulting as needed.

4.8 SV: Scientific Visualization (NCSA – Illinois)

The PET Visualization team at the ERDC MSRC was led by the National Center for Supercomputing Applications (NCSA) at The University of Illinois. Dr. Polly Baker (NCSA) serves as Senior Academic Lead, providing long–term direction and leadership for the effort. Dr. Alan Shih (NCSA) serves as NCSA project lead. Dr. Mike Folk (NCSA) introduced expertise in data management and efficient storage during Year 4. Dr. Richard Strelitz (SAIC/CSC) served as primary liason between the academic personnel and the users at the ERDC MSRC during Year 4.

The PET Vis team interacts with end users to define user needs, provide information on available solutions, and prototype custom solutions where necessary. The team also coordinates with other ERDC MSRC personnel specializing in visualization.

5. Year 4 Accomplishments

As has been noted above, the PET effort at the ERDC MSRC operates through providing core support to ERDC MSRC users, performing specific focused efforts designed to introduce new tools and computational technology into the ERDC MSRC, conducting training courses and workshops for ERDC MSRC users, and operating an HBCU/MI enhancement program.

The major accomplishments of the ERDC MSRC PET effort in enhancing the programming environment at the ERDC MSRC are described in this section. The presentation here is according to CTAs and technical infrastructure support areas, but there is much overlap in effort.

Tools introduced into the ERDC MSRC in the course of Year 4 of the PET effort are listed in Table 4, and are described in Section VI. Specific ERDC MSRC codes impacted by the PET effort during Year 4 are listed in Table 5, and items of technology transfer into the ERDC MSRC are listed in Table 6. More detail on the Year 4 effort is given in the ERDC MSRC PET Technical Reports and other publications from Year 4 that are listed in the Sections 10 and 11. Training conducted during Year 4 is described in Section 7, and outreach to ERDC MSRC users is covered in Section 8. The accomplishments in the HBCU/MI component of the ERDC MSRC PET effort are discussed in Section 9.

5.1 CFD: Computational Fluid Dynamics CTA (ERC–Mississippi State)

Primary Core Support contributions were made during Year 4 by the On–Site Lead (Bova, later Prewitt) and the Senior Academic Lead (Soni). There were no Focused Effort projects executed during Year 4. There were major changes in the CFD support team during Year 4 as Dr. Bharat Soni of MSU became Senior Academic Lead for CFD at ERDC MSRC, as he has been for the ASC and ARL MSRCs from the start of he PET program. This greatly increases the continuity and coordination of CFD support across these three MSRCs. Also during Year 4 Dr. Steve Bova, who had been the CFD On–Site Lead at ERDC MSRC since the beginning of PET, left for Sandia National Lab. After several months of vacancy in the CFD On–Site Lead, Dr. Nathan Prewitt came into this position from Sverdrup at Eglin Air Force Base.

5.1.1 Core Support: Outreach, Tech–Transfer and Training

The Core Support involving outreach, technology transfer, training, and technology improvements was provided as a team effort between Steve Bova, Bharat Soni and Nathan Prewitt. Concentration in Year 4 was placed on supporting the CFD CHSSI software. In particular, parallel tools and visualization support was provided to OVERFLOW_D (Dr. Robert Meakin) and FAST3D (Dr. Jay Boris). A CFD CHSSI software overview workshop was offered as a joint effort among the ARL, ASC and ERDC PET programs. CHSSI software developers and the CFD PET team were involved in presentations. A one–day workshop was held as a pre–conference program associated with the 38th AIAA Aerospace Sciences meeting in Reno, Nevada, in January. Approximately 40 DoD practioners participated in this all–day workshop. The workshop was very successful and provided an excellent opportunity for outreach and transfer of CFD CHSSI software technology to the DoD community at large.

Dr. Soni presented seminars on CFD in the HPC environment at Clark Atlanta University during their summer institute and at Morgan State University. At Morgan State University, a “hands on”

CFD experience was provided to students and faculty using Java–based CFD tools. Drs. Soni and Bova, with the help of MSU researchers, Drs. Roy Koomullil and David Thompson, conducted a CFD day at the JSU summer institute. Lectures along with interesting applications were presented in the morning and “hands on” experiences with CFD application execution processes were provided in the afternoon. The Java–based exercises were very useful in demonstrating flow field characteristics and the importance of simulation. MSU’s hybrid grid–based flow solver and grid generation software were utilized to demonstrate the simulation process to these students.

The ARL, ASC and ERDC MSRCs jointly sponsored a poster session at the 8th International Meshing Roundtable held in South Lake Tahoe, California, in October. The conference was attended by 110 researchers from various countries. The poster session provided a very good forum for MSRC outreach. Dr. Soni was one of the instructors at the pre–coference short course on grid generation. The grid course was attended by 45 attendees and was very successful.

Outreach visits to Redstone Arsenal and the Air Force Arnold Engineering Development Center were taken. A discussion of the PET program and support activities with CFD users Clark Mikkelsen and Kevin Kennedy at Redstone were held. The generalized grid–based technology and a feature detection algorithm under development at MSU under an NSF grant will be transferred to Redstone. A WIND (CHSSI code) consortium meeting was held at AEDC. The CFD PET program from ARL, ASC and ERDC MSRCs is participating in this consortium. A large–scale project on terascale visualization and feature detection has been initiated under an NSF grant at the ERC. The large–scale ERDC data sets will be used for validation in this project. The algorithms and software developed as part of this project will be available to ERDC MSRC.

5.2 CSM: Computational Structural Mechanics CTA (TICAM–Texas, with ERC–Mississippi State)

The principal goal of this CSM effort is to introduce, implement and test adaptive grid techniques for analysis of CSM problems for DoD simulation of “violent events” such as those encountered in blast and hypervelocity impact studies and the related problem of analysis of damaged structures. Also of interest are work on new algorithms and techniques related to large scale parallel simulation of these classes of computationally intensive and complex applications. Representative DoD codes include CTH and EPIC, as well as interfacing such simulations to other analysis codes.

This work requires consideration of the following: (1) appropriate a posteriori error estimates and corresponding indicators for these problem classes; (2) strategies for adapting the grid by refinement, coarsening, and redistributing or smoothing strategies; (3) complications in implementing the adaptive schemes related to the form of “legacy code”; (4) development and incorporation of appropriate data structures for adaptive refinement and coarsening; (6) development of indicators to assess the degradation in the quality of the elements during simulation as the grid is refined or deforms; (5) efficiency in implementation; and (6) parallel, scalable HPC needs with respect to partitioning for domain decomposition and for parallel adaptive simulation.

Our Core Support and Focused Effort research activities on the project have been targeted to these goals and we have made several significant progress accomplishments:

5.2.1 Block Refinement/Unrefinement Adaptive Strategy—CTH

We have developed a 2:1 block refinement/unrefinement adaptive strategy and implemented it in a new prototype version of CTH. This has been tested on some standard benchmark hyper–velocity impact problems and comparison studies have been made of performance against the conventional uniform grid simulation. These tests demonstrate the advantages of the adaptive approach for this class of problems and in particular for blast applications and penetrator problems where very strong localised effects dominate in the simulations. Preliminary calculations have been carried out as part of the code development and verification testing process. An example from one of these simulations, the propagation of a 2D blast wave through air, took 1.8 hours to complete. A corresponding uniform mesh version of this problem was also run; it produced almost identical results to the ones shown here but took 145 CPU hours to complete. A second example is the impact of an aluminum sphere at 5 km/s on an aluminum plate, with refinement and de–refinement so that the highest resolution mesh follows the fragments. This work is being expanded to include parallel distributed simulations and is being carried out jointly with Dave Crawford and the CTH development team at Sandia. A new release of CTH with these added capabilities is scheduled for Year 5.

As part of the work we are also developing new error and feature indicators to guide refinement and assess computational reliability.

5.2.2 Local Simplex Refinement Strategy–EPIC

We have developed a local simplex refinement strategy–EPIC and implemented it in the test code EPIC (Elasto Plastic Impact Computation). As the simulation proceeds, elements are locally refined based on element feature and error indicators. In this lagrangian calculation, the element shape degrades as the calculation proceeds and elements near the impact zone deform. Part of our current work here has focused on the important question of element shape integrity and its effect on the accuracy and efficiency of the simulation. More specifically, as the elements deform, the local accuracy deteriorates and the timestep is adversely affected. Refining the element by bisecting the longest side can help restore element shape quality, but the timestep for the explicit scheme is reduced as the elements become smaller. We have been investigating element shape indicators and testing them for this class of applications. The basic idea is to monitor both solution error indicators and element shape indicators. Two new candidate “hybrid ” indicators based on this notion have been suggested and are being tested for the “Taylor Anvil” impact problem to assess the utility of the approach.

5.2.3 Framework for Testing Error Indicators–CTH

We have developed a framework for testing error indicators in codes such as CTH. This framework, called the “Testbed”, separates the physics kernels from the data structure and adaptive components and therefore enables the analyst to more rapidly and easily test new indicators. The goal here is to provide a capability for testing indicators and algorithms for adaptive mesh refinement and then transferring the successful schemes to CTH and similar DoD codes. A new class of residual indicators has been developed and the underlying theory established. The Testbed has been demonstrated on a sample adaptive calculation and will be more extensively applied. The work on parallel algorithms and support has focused on the parallel adaptive strategies mentioned above and on the use of partitioning strategies for unstructured grids in both the eulerian and lagrangian settings. In particular, we have carried out studies using the meshes generated in the lagrangian impact simulation studies using the partitioner CHACO and with a space–filling curve capability we have added to this partitioning package. Comparative Studies of the partitioning algorithms have been conducted.

The above studies are significant since the error indicators are new and the work on adaptive methodology and algorithms provides a major advance in capability for this class of problems and applications codes. They therefore constitute a strong statement concerning the main PET program goal – to introduce and tech transfer advanced adaptive grid strategies from the university and research labs to the DoD application groups.

5.2.4 Core Support

This work has been closely coordinated with our Core Support activities. Professor Carey gave a related short course on Computational Grids with a focus on unstructured grids and adaptive techniques at ERDC MSRC. Dr. Oden led a second mini–seminar course at ERDC MSRC on the subject of "Meshless" methods. A Workshop on Advances in Unstructured Adaptive Grids and Supporting Technology was held at Austin at the close of the previous period, and the Workshop proceedings report was prepared at the beginning of this funded period. Dr. Littlefield and Dr. Weed conducted a workshop at Jackson State on the applications problem class and solution on parallel supercomputers. Results of the research were presented at the mid–year review by Dr. Weed and at the annual review by Drs. Oden, Carey, Weed and Littlefield. In addition we have continued to work closely with Sandia researchers and made several working trips to Sandia to foster the collaboration and expedite the work.

This Core Support together with the Focused Efforts constitute a cohesive approach that includes the Texas researchers, the Army Institute for Advanced Technology activities, Sandia applications and software development, and ERDC applications using CTH and EPIC. The work has a strong impact on DoD applications and the MSRC since it promises to change the entire approach for solving these problems in a timely and more reliable way. It will significantly impact the MSRC user group by permitting more extensive simulation tests in a practical timeframe and enabling sensitivity studies to be carried out over a range of parameters. This was really not feasible in the past. The ideas and capability we are providing can also be used to great advantage on smaller stand–alone and secure PC Cluster systems, and part of our continuing work will explore such configurations.

In addition to TICAM's accomplishments in Core Support and Focused Effort activities, the past year was a very productive one for On–Site Core Support. During the past year, Dr. Weed taught or co–taught two Parallel Programming Workshops. The first of these workshops was taught with Dr. Henry Gabb at New London, Connecticutt for ERDC MSRC, reaching users from the Bolt, Beranak, and Neumann (BBN) and Grumman Electric Boat Companies. The second workshop was conducted at the request of ERDC Structures Lab personnel to support the development of a parallel version of the EPIC penetration analysis code by ERDC Structures Lab contractors. In conjuction with the second workshop, Dr. Weed performed a preliminary parallelization of the EPIC code using the OpenMP parallel programming interface on the ERDC MSRC SGI Origin 2000 system. This work was used as an example in the workshop and also provided a starting point for the development of a complete parallel version by Alliant Systems personnel.

The second major accomplishement of the On–Site Lead was the development of a suite of Fortran and C programs that simplifies the implementation of loosely coupled multidisciplinary applications using the Message Passing Interface (MPI) message passing libraries on ERDC MSRC computing platforms. This software was developed to support CHSSI code development project (CHSSI EQM 1) of Dr’s Bob Bernard and Charlie Berger of the ERDC Coastal Hydraulics Laboratory (CHL). The software provides a simple user interface for coupling two stand–alone codes into a multi–disciplinary application on parallel computers. This work was documented in two ERDC MSRC PET Technical Reports.

5.3 CWO: Climate/Weather/Ocean Modeling CTA (Ohio State)

The PET Year 4 efforts of the Ohio State University CWO team followed two main paths. These are the ongoing development of a multi–physics, coupled marine modeling system, which is relevant to a range of user–communities at ERDC MSRC, and the integration of PET wave model development activities into the overall strategic plan of the CHL wave modeling group. In both cases, the emphasis of CWO efforts has shifted further towards a return on investment as the PET program reaches the latter stages of its initial five–year mandate.

5.3.1 Multiphysics, Coupled Marine Modeling System

In the past project year, the coupled modeling system involving the WAM wind– wave model, the CH3D–SED circulation and sediment transport model, and the WCBL combined wave–current marine boundary layer model, has been upgraded in terms of physics and computational performance. These upgrades were implemented within the context of system deployment in the Adriatic Sea, a basin of significant military interest which was selected after consultation with MSRC users and PET management. Specifically, the coupled system was upgraded by moving from one–way coupling, with WAM wave predictions read from file, to full two–way coupling with WAM, CH3D–SED, and WCBL models running simultaneously and synchronized exchange of arrays at a user–defined coupling frequency. Furthermore, the WCBL model written in PET Year 3 has now been parallelized using the MPI library. In the coupled system, WCBL functions as a boundary–layer sub–model which accepts current field and sediment concentration inputs from CH3D–SED and wave field inputs from WAM, then simulates the nonlinear interaction of wave, current, and sediment boundary layers before returning combined roughness height, friction factor, and shear stress arrays for use by CH3D–SED and WAM. Since CH3D–SED and WAM must wait while WCBL makes calculations, WCBL has been deployed as a subroutine of CH3D– SED which uses the same domain decomposition and processors.

The interactions of the wave, current, and sediment boundary layers are most significant in shallow water, where wave motions are strongly felt at the marine bed. In these circumstances, the use of WCBL allows the potentially dominant influence of wave–induced bottom roughness to be accounted for in the predictions of CH3D–SED. This can lead to more accurate, (much–increased), sediment transport and concentration predictions. The coupled system now accounts for interactions between the different fields of motion at both the marine bottom and air–sea boundary layers; the latter couplings were developed in PET Years 1 and 2.

The Adriatic Sea deployment of WAM/CH3D–SED/WCBL was achieved with the help of DoD CWO scientists at ERDC and other sites. Dr. Robert Jensen of ERDC CHL helped the OSU team obtain bathymetry files, while Dr. Rich Hodur of NRL–Monterey (project leader for the Navy COAMPS atmospheric circulation model) supplied Adriatic Sea modeled wind fields and heat fluxes. Dr. Michael Brooking of NRL–Stennis arranged ongoing access to Adriatic Sea wave data for system evaluation. This wide involvement is indicative of the range of impact the coupled system is likely to have. The system offers upgrades in predictive accuracy to users of both WAM and CH3D–SED, and introduces an integrated modeling capability that was previously unavailable. To this end, Dr. Joe Gailani of ERDC CHL has requested that the WAM/CH3D–SED/WCBL system be used to provide numerical modeling support for a dredged material disposal experiment scheduled for the ERDC Field Research Facility in the 2000 field season. Dr. Peter Orlin of NAVOCEANO is also interested in using the system for the simulation of riverine sediment plumes. The coupled system will be evaluated by ERDC CH3D–SED and WAM users including Dr. Jeff Holland and Dr. Robert Jensen, respectively. This will permit comprehensive, independent evaluation, allow potential users to become familiar with the system, and lead to system modifications targeted at practical user needs.

5.3.2 Integration of PET Wave Model Development Activities

In PET Year 4, the OSU CWO team developed a closer relationship with the wave modeling group at ERDC CHL. This resulted from outreach to the CHL waves group while they were in the process of formulating a comprehensive wave–modeling strategy to coordinate their efforts and resources across a number of DoD programs. The PET CWO team was presented as an available resource, which lead to an integrated plan for the development of CHL wave–modeling capabilities. The overall theme of the plan is to develop and evaluate a suite of advanced wave models which are suited to particular water depth regimes and are linked by common interface structures which allow the seamless passing of boundary conditions between model deployments covering different scales of grid coverage and resolution. Wave models can be classified as deep water, generational scale; shallow water, transformational scale; or nearshore, local scale models. Different physics and numerical strategies are appropriate in each case.

To support the CHL waves group's strategic plan, OSU Year 4 efforts included an evaluation of the SWAN shallow water wave model and its boundary condition interface to the WAM deep water wave model. This work led to the identification and correction of a number of problems in the WAM/SWAN interface. The improvement of the interface was carried out in close cooperation with the SWAN development team at the Delft University of Technology. WAM user Dr. Robert Jensen helped establish this relationship and also helped OSU organize a week–long visit to ERDC of Dr. Ijsbrand Haagsma of the SWAN development team. The recently completed WAM/SWAN study resulted in a fully tested interface and the evaluation of WAM and SWAN accuracy in the simulation of shallow water wave activity related to 1995 Hurricane Luis. The test case bathymetry, wind fields, wave observations, and original three–nest WAM deployment were provided by Dr. Robert Jensen. The CWO team then deployed SWAN on the finest nest and generated WAM and SWAN predictions for various finest–nest grid resolutions and different SWAN physics options. Statistics of predictive accuracy were generated using deep and shallow water wave data, and as a result, the importance of various optional SWAN physics algorithms were identified.

The net result of this work is that CHL wave modelers will be able to improve the accuracy of shallow water wave predictions by deploying SWAN sub–nests and selecting optimum physics settings.

5.4 EQM: Environmental Quality Modeling CTA (TICAM – Texas)

The activities of the EQM team can be classified into four major categories: (1) coupling of multi–physics codes, treating both theoretical and implementation aspects (2) identification and presentation of new novel algorithms for advection/diffusion/reaction with application to environmental modeling (3) debugging, validation, and evaluation of codes (4) enhancements of major environmental modeling software.

5.4.1 Coupling of Multi–Physics Codes

An example of the multi–physics coupling arises in the numerical modeling of fluid flow and transport problems where the computed velocity field frequently needs to be projected from one grid to another between different models. Generally the hydrodynamic flow and multi–species transport are solved separately using completely different numerical methods and grids, due to differences in length and time scales of the phenomena involved. For accurate transport, it is necessary for the velocities to be locally conservative on the transport grid. Lack of local mass conservation results in spurious sources and sinks to the transport equation. Many of the hydrodynamics codes employed in coastal studies (e.g. ADCIRC, TABS–MDS) are not locally conservative. Local mass conservation, as well as using completely different grids, can be accomplished through a projection algorithm which was formulated and analyzed by Dawson and Wheeler.

During the past year, a 3D projection code called UTPROJ has been developed and has been applied in coupling TABS–MDS with CE–QUAL–ICM. Time averaging and volume changes were also incorporated in the coupling (not part of the original proposed effort). This software can also be applied to other hydrodynamic and/or subsurface couplings with reactive transport codes. A future possible application may be EQM support to the NGLI (Northern Gulf of Mexico Littoral Initiative) project.

5.4.2 Identification and Presentation of New Novel Algorithms

Several computer science enabling technologies for coupling a wider range of physical processes in a model have also been investigated.

This work, while not funded under the PET project, was presented in a parallel algorithms workshop organized by PET EQM. This includes ADR (Active Data Repository) and Metachaos developed by Dr. Joel Saltz of Johns Hopkins and the University of Maryland, KeLP by Dr. Scott Baden of the University of California at San Diego, and Globus/Nexus by Dr. Carl Kesselman of the University of Southern California. ADR enables integration of storage, retrieval, and processing of multiple multidimensional datasets on parallel machines and provides support for spatial queries and complex data aggregations. Metachaos is a software tool for loose coupling of different codes. The KeLP library provides very efficient tools for coupling multi–domain problems, and Globus/Nexus has been applied for handling hetereogeneous parallel simulation. Results have been obtained coupling the hydrodynamics code ADCIRC, a 2D version of UT-PROJ, and the transport code UTTRANS using ADR and Metachaos. KeLP is being applied in the domain decomposition solver of UTPROJ.

In the workshop on algorithms, Wheeler and Dawson presented their results on a novel collection of new discretization methods known as the discontinuous Galerkin (DG) finite element methods. These new approaches use completely discontinuous finite element spaces, allowing for use of non–matching finite element grids, and different approximating polynomials in different elements (p–adaptivity). Wetting and drying of elements, which is a difficulty in many older surface water simulators, are easily handled with the DG methods, since all computations are element–based with only weak coupling between elements. The DG methods also conserve mass and momentum locally and can easily treat full tensors and general boundary conditions for advection/diffusion/reaction problems. In addition, for smooth problems exponential rates of convergence can be shown both theoretically and computationally. These methods show great promise in addressing many of the difficulties that are present in the hydrodynamics and porous media software being employed today.

5.4.3 Debugging, Validation, and Evaluation of Codes

The third major activity of the EQM team has been in the area of debugging, validation, evalutation of codes. One specific code, the water–quality code CE–QUAL–ICM, was targeted in a study of scalability. Here we used PAPI to evaluate MFLOPs on the Cray T3E, and VAMPIR to evaluate message passing and I/O efficiencies. Based upon this information, a redesign of the message–passing interface was initiated, and the parallel–I/O capability of MPI–2 was employed to reduce the number of open files in large processor jobs. The impact of this was to improve the performance of CE–QUAL–ICM (and also CE–QUAL–TOXI) to a 20–times speed–up on 32 processors. Similar studies led to an improved performance of ADCIRC to 110–times speed–up on 128 processors.

5.4.4 Enhancements of Major Environmental Modeling Software

Our fourth activity involved enhancement of major coastal engineering software; namely the codes CH3D and the POM Ocean Circulation Model.

CH3D–Z is a widely used hydrodynamics code. Recently, there have been several attempts to parallelize the code for distributed memory platforms. These efforts have met with limited success, primarily due to the underlying time–stepping procedure used in the code. CH3D uses a staggered grid approximation for surface elevation and depth–averaged velocities. Within a given time step, the code solves first for the x–component of velocity and an intermediate surface elevation by performing an x–sweep. Then the y–component of velocity and elevation are computed by performing a y–sweep. This procedure is inherently sequential and thus very difficult to parallelize.

We have replaced this time–stepping approach by substituting the discrete equations for x– and y–velocities into the continuity equation, giving rise to a linear system of equations for surface elevation. This system is then solved using a non–symmetric preconditioned conjugate gradient procedure, in particular Jacobi–preconditioned orthomin from the NSPCG package. Once surface elevations are known, then velocities are computed in a post–processing step.

Because CH3D uses a structured grid, the discrete continuity equation results in a five–point stencil for surface elevations. Mass lumping is used for velocities; thus their computation is completely local. Therefore, the overall method has a very compact stencil. This algorithm can be easily parallelized in the future using mesh/data partitioning and standard message passing techniques, similar to what we have done in the past for CE–QUAL–ICM and ADCIRC.

The solver has been implemented and is currently being tested on the Chesapeake/Delaware data set. Comparisons to results of the original version of the code are being made. A user's guide to the modified code will soon be completed.

As mentioned above, with the help of Breshears and Gabb (of the PET on–site team at ERDC MSRC), the 1–D domain decomposition of CH3D using MPI was modified to allow for dynamic allocation of blocks assigned to processors and a MPI/OpenMP version developed. A nearly two times speed up was gained from these modifications. These results are discussed in more detail in a PET technical report.

In addition, with the assistance of Breshears and Dr. L.N. Ly of the Naval Postgraduate School, MPI and OpenMP dynamic threading were employed in the parallel migration of the Multi–Block Grid POM Ocean Circulation Model. The MPI version acheived 20–times speed–up over a single processor one–block grid. The MPI/OpenMP version gained a 45–times speed–up for a 20–block grid over the one–block grid. These results are described in a PET technical report.

In summary, major improvements in speed–up were acheived on codes that are critical in engineering coastal and subsurface studies. Essential software was developed to allow validated hydrodynamic codes to be employed in environmental studies in Cheseapeake Bay, Florida Bay and future EQM support to the NGLI project. Furthermore, new algorithms and computer science methodologies were introduced for addressing future needs of multi–physics, multi–domain science instead of the present "one–process–at–time" modeling.

5.5 FMS: Forces Modeling and Simulation/C4I CTA (NPAC – Syracuse)

Using our WebHLA framework described in our previous PET annual reports and lessons learned from previous experiments with Parallel CMS, we addressed in Year 4 the full challenge of Parallel and Distributed, hence Metacomputing, CMS system that extends the sequential CMS simulator from Ft. Belvoir towards large–scale minefields on the order of a million and more active mines. The full effort, started in previous years and brought in Year 4 to a successful scalable large–scale metacomputing prototype and demonstration included: a) converting the CMS system from the DIS to HLA framework; b) constructing scalable Parallel CMS federate for Origin2000; and c) linking it with ModSAF vehicle simulator and other utility federates towards a Metacomputing CMS federation. Converting Parallel CMS to HLA using our WebHLA framework was accomplished in Year 3 and was described in previous PET reports. Here we describe the two main thrusts of our Year 4 effort: Scalable Parallel CMS and Metacomputing CMS Federation.

5.5.1 Scalable Parallel CMS

In our first attempts to port CMS to the Origin2000, conducted in previous years, we identified performance–critical parts of the inner loop, related to the repetitive tracking operation over all mines with respect to the vehicle positions, and we tried to parallelize it using the Origin2000 compiler pragmas (i.e. loop partition and/or data decomposition directives). Unfortunately, this approach delivered only very limited scalability for up to 4 processors. We concluded that the pragmas–based techniques, while efficient for regular Fortran programs, are not very practical for parallelizing complex and dynamic object–oriented event–driven FMS simulation codes – especially the 'legacy' object–oriented codes such as CMS which were developed by multiple programming teams over a long period of time with complex dynamic memory layouts of numerous objects that are now extremely difficult to decipher and properly distribute.

In the follow–on effort, conducted in Year 4, we decided to explore an alternative approach based on a more direct, lower–level parallelization technique. Based on our analysis of the SPEEDES simulation kernel that is known to deliver scalable object–oriented HPC FMS codes on the Origin2000 (such as the Parallel Navy Simulation System under development by Metron), we constructed a similar parallel support for CMS. The base concept of this 'micro SPEEDES kernel' approach, borrowed from the SPEEDES engine design but prototyped by us independently of the SPEEDES code, is to use only the fully portable UNIX constructs such as fork and shmem for the inter–process and inter–processor communication. This guarantees that the code is manifestly portable across all UNIX platforms, and hence it can be more easily developed, debugged and tested in the single–processor multi–threaded mode on sequential UNIX boxes.

In our micro–kernel, the parent process allocates a shared memory segment using shmget() and then it forks n children, remaps them via execpv(), and passes the shared memory segment descriptor to each child via the command line argument. Each child attaches to its dedicated slice of the shared memory using shmat(), thereby establishing the highest possible performance (no MPI overhead), fully portable (from O2 to O2K) multi–processor communication framework. We also developed a simple set of semaphores to synchronize node programs and to avoid race conditions in critical sections of the code. On a single–processor UNIX platform, our kernel, when invoked with n processes, generates in fact n concurrent threads, communicating via UNIX shared memory. In an unscheduled Origin2000 run, the number of threads per processor and the number of processors used are undetermined (i.e. under control of the OS). However, when executed under control of a parallel scheduler such as MISER, each child process forked by our parent is assigned to a different processor, which allows us to regain control over the process placement and to realize a natural scalable implementation of parallel CMS.

On top of this micro–kernel infrastructure, we put suitable object–oriented wrappers that hide the explicit shmem–based communication under the suitable higher–level abstractions so that each node program behaves in fact as a sequential CMS, operating on a suitable subset of the full minefield. The CMS module cooperates with the ModSAF vehicle simulator running on another machine on the network. CMS continuously reads vehicle motion PDUs from the network, updates vehicle positions and tracks all mines in the minefield in search for possible explosions. In our parallel version, the parent node 0 reads from the physical network and it broadcasts all PDUs via shared memory to children. Each child reads its PDUs from a virtual network which is a TCP/IP wrapper over the shmem communication channel.

Minefield segments are assigned to individual node programs using the scattered/cyclic decomposition which guarantees reasonable dynamic load balancing regardless of the current number and configuration of vehicles propagating through the minefield. We found the CMS minefield parser and the whole minefield I/O sector as difficult to decipher and modify to support scattered decomposition. We bypassed this problem by constructing our own Java–based minefield parser using the new powerful public domain Java parser technology called ANTLR and offered by the MageLang Institute. Our parser reads the large sequential minefield file and chops it into n files, each representing a reduced node minefield generated via scattered decomposition. All these files are fetched concurrently by the node programs when the parallel CMS starts and the subsequent simulation decomposes naturally into node CMS programs, operating on scattered sectors of the minefield and communicating via the shmem micro–kernel channel described above.

We performed timing runs of Parallel CMS, using the Origin2000 systems at the Naval Research Laboratory in Washington, DC, and at the ERDC MSRC at Vicksburg, MS. The performance results we obtained indicate that we have successfully constructed a fully scalable Parallel CMS for the Origin2000 platform. We were running Parallel CMS for a large minefield of one million mines, simulated on 16, 32 and 64 nodes, and we were analysing both the total simulation time to determine speedup and the simulation times on individual nodes to determine load balance. We couldn't run our million mines simulation for less than 16 nodes due to node memory limitations. For runs on 16, 32 and 64 nodes we obtained almost perfect (linear) scaling over broad range of processors and very satisfactory load balance in each run.

5.5.2 Metacomputing CMS Federation

The timing results described above were obtained during Parallel CMS runs conducted within a WebHLA–based HPDC environment that spanned three geographically distributed laboratories and utilized most of the WebHLA tools and federates discussed in our previous PET reports. The overall configuration of this initial Metacomputing CMS environment included ModSAF, JDIS (our DIS/HLA bridge), Parallel CMS, logger/playback federate such as PDUDB and control/visualization federates such as SimVis. ModSAF, JDIS and SimVis modules were typically running on a workstation cluster at NPAC in Syracuse University. The JWORB/OWRTI–based Federation Manager was typically running on Origin2000 at ERDC MSRC in Vicksburg, MS. The parallel CMS federate was typically running on Origin2000 at NRL in Washington, DC. Large MISER runs at NRL need to be scheduled in a batch mode and are activated at unpredictable times, often in the middle of the night. This created some logistics problems since ModSAF is a GUI based legacy application that needs to be started by a human pressing the button.

To bypass the need for a human operator to continuously monitor the MISER batch queue and to start ModSAF manually, we constructed a log of a typical simulation scenario with some 30 vehicles and we played it repetitively from the database using our PDUDB federate. The only program running continuously (at ERDC MSRC) was the JWORB/OWRTI–based Federation Manager. After the Parallel CMS was started by MISER at NRL, it joined the distributed federation (managed at ERDC MSRC) and automatically activated the PDUDB playback server at NPAC that started to stream vehicle PDUs to JDIS which in turn converted them to HLA interactions and sent (via RTI located at ERDC MSRC) to the Parallel CMS federate at NRL. Each such event, received by node 0 of Parallel CMS was multicast via shared memory to all nodes of the simulation run and used there by the node CMS programs to update the internal states of simulation vehicles. The inner loop of each CMS node program was continuously tracking all mines scattered into this node against all vehicles in search of possible explosions.

Having constructed the scalable Parallel CMS federate and having established a robust Metacomputing CMS experimentation environment, we proceed now with the next set of experiments towards wide area distributed large scale FMS simulations, using CMS as the application focus and testbed. In the first such experiment, we intend to distribute large minefields of millions of mines over several Origin2000 machines in various DoD labs using domain decomposition, followed by the scattered decomposition of each minefield domain over the nodes of a local parallel system. So far, we have obtained first results for Distributed Parallel CMS with 30K mine domains of a 60K mine minefield distributed over Origins in ERDC MSRC and NRL facilities. Parallel CMS runs for minefields larger than 30K mines need to be executed via local batch queues and hence a robust metacomputing operation would require global synchronization between such schedulers which is the subject of one of our Year 5 tasks. Our other planned effort includes support for parallel object–oriented programming tools and visual authoring environments. We identified the need for such tools both in our own work on Parallel CMS and in discussions with other FMS teams such as Metron Corporation. Major requirements include Web/Commodity base, HLA compliance and OOA&D standards compliance. We propose to accomplish it by integrating our previous WebFlow and WebHLA efforts with the new industry standards for object analysis and design such as UML (Uniform Modeling Language).

5.6 C/C: Collaboration and Communications (NPAC – Syracuse)

NPAC's efforts in this area encompass not just Collaboration and Communication per se, but also the closely related area of tools and technologies for training and education. The NPAC team is also involved in analogous support activities in the ARL MSRC and ASC MSRC PET programs, as well as having a modest involvement in distance training and education activities in conjunction with the NAVO MSRC PET program. These additional connections provide a great deal of synergy with C/C activities sponsored by ERDC MSRC.

5.6.1 Computing Portals

As in the past, our work in Year 4 has been dominated by work on tools and techniques for remote collaboration, training, education, and distributed computing. But we are beginning to think about these ideas differently. The concept of "portals" has recently emerged in the Internet community at large as sites that provide gateways to a variety of tools and resources connected by a given theme. In the context of the DoD HPCMP, "computing portals" and "education (training) portals" are two areas of definite interest.

A "computing portal" is typically designed as a three–tier system in which a user front–end is linked to a set of "back–end" software and computing resources through a collection of middleware. This is intended to facilitate the development and use of complex software systems in a network–based computing environment. These environments are becoming increasingly popular in part because there now exists a variety of powerful commodity technologies which facilitate the development and implementation of such portals: HTTP and web browsers, Java, CORBA (common object request broker architecture), XML (extensible markup language), etc. These ideas and technologies are at the heart of our work with the ERDC Coastal and Hydraulics Lab on the Land Management System (LMS). LMS integrates a number of existing (legacy) modeling and visualization tools into a unified environment which allows the user interface, database access for input data, and computational resources to be run in distributed fashion over the network. It also facilitates coupling multiple modeling applications into a "meta–application" without the need to modify the legacy codes involved. Extending our work of last year, when we produced a prototype LMS system based on a previous generation of technologies, the system has now been reimplemented using a commodity Java/CORBA/HTTP/XML environment. The framework has also been generalized to facilitate the incorporation of additional simulation packages, visualization tools, and input data sources.

Portals for education and training, like those for computing, are typically thought of in terms of individual users and at best "asynchronous" collaboration between portal users — interactions which don't require the parties involved to be online simultaneously, such as e–mail or web–based discussion forums. However our extensive work on synchronous collaboration and education over the past several years has given us insights into how portals might be made collaborative (both asynchronously and synchronously) in an incremental fashion and extended to interact with a wider range of access devices according to the requirements and limitations of both the device and the user. One such project undertaken this year involved the linking of handheld personal digital assistant devices (i.e. Palm IIIx, and Casio E–100) to the Tango Interactive collaboratory system in order to study how mobile access to computing and education portals might be facilitated.

5.6.2 Distance Learning

Other work on collaboration, and especially interactive synchronous distance learning continues to focus on the Tango Interactive collaboratory tools. Tango Interactive is a framework that allows sharing of applications across the Internet. It includes a suite of tools useful for basic collaboration and distance learning activities: shared web browser, chat, whiteboard, audio/video conferencing, shared text editor, etc. It also provides an application program interface (API) that allows other applications to be hooked into the Tango framework.

Continuing our collaboration with ERDC MSRC PET partner Jackson State University (JSU), we have expanded our distance education offerings to include additional sites. This year's offerings, the fifth and sixth semester–long academic credit courses offered over the network using Tango, were received not only by JSU, but also by Morgan State University (involved in the ARL and NAVO MSRC PET programs), Mississippi State University (another ERDC MSRC PET partner), all four MSRCs, and NRL–DC, reaching an unprecedented number of students. Training events using Tango have also become part of the mainstream of the ERDC MSRC PET Training program, providing a mechanism to reach more users and reduce travel.

Our experiences with Tango Interactive in interactive synchronous distance education/training, as well as collaboration will also factor into future work on collaborative education and computing portals.

5.7 SPP Tools: Scalable Parallel Programming Tools (Rice and Tennessee)

5.7.1 Rice

5.7.1.1 Tutorials

Concurrent Programming with Pthreads

Clay Breshears and Henry Gabb developed and presented this tutorial at Rice University (March 29–31, 1999), ERDC MSRC (July 27–28, 1999), and SC99 (November 15, 1999).

Significance: Pthreads is a POSIX standard library for multi–threading. Tasks are assigned to threads that execute concurrently. With the increasing use of shared–memory cluster–based HPC platforms, a shared–memory programming model could be a more effective solution within individual clusters. Pthreads is such a programming model.

Migration of STWAVE and SWAN (CWO codes)

A CWO–related tutorial and materials were delivered to ERDC MSRC employees and contractors Jane Smith, Ann Sherlock, Steve Wornom, and Lori Hadley. Instructors for the tutorial were Richard Hanson and Ehtesham Hayder (both of Rice University). The tutorials were given on April 21–23, 1999, at Rice University, with five sessions over 2.5 days. Each session was concerned with the application codes STWAVE and SWAN. The first session dealt with conversion to Fortran 90. The second and third sessions identified the parallelism in the STWAVE code and how to exploit this with message passing methods. The fourth session dealt with a required root solving method, mathematical software, memory hierarchy efficiency, project planning, and regression testing. The last session concerned actual edits to the code. Comments were inserted into the code pertaining to upgrades or changes required. The slides and edited codes were provided to the participants.

Follow–up: Clay Breshears worked with Ann Sherlock on performance analysis of the STWAVE code. In addition, plans for migrating the serial code to a parallel distributed version were outlined. Breshears continues to be available for STWAVE and SWAN researchers as needed. Richard Hanson worked on analysis of the time spent in elementary functions within STWAVE. It was noted that a large part was devoted to evaluation of the Sine and Cosine functions. He gave ways to significantly speed these up.

5.7.1.2 Installed Tools

ScaLAPACK: Parallel linear algebra library. This library, along with the BLACS (Basic Linear Algebra Communication Subroutines), is available on all ERDC MSRC HPC platforms.

SuperLU: Sparse, direct solver library. Breshears built and installed updated versions of the SuperLU sparse direct solver libraries on the appropriate ERDC MSRC HPC platforms.

Vampir: Graphical performance analysis tool. The Vampir tool was used by Dr. Phu Luong (On–Site EQM Lead) to determine candidates for loop–level OpenMP parallel directives in CH3D–SED code and by Dr. Victor Parr (TICAM) to examine I/O and MPI communication time within the CE–QUAL–ICM code.

5.7.1.3 Other Applications

CH3D–SED: Breshears collaborated with Dr. Phu Luong (On–site EQM Lead) and Henry Gabb on adding OpenMP directives to the MPI version of the CH3D–SED with one–dimensional domain decomposition. This code was run using data for the New York Bight in order to show how OpenMP parallelism could be used for automatic load balance of applications. This work was presented in the poster presentation "Dual–Level Parallelism Improves Load Balance in the Production Engineering Application CH3D–SED" at the SC99 conference, Portland, OR, November 18–20, 1999.

Princeton Ocean Model: Breshears collaborated with Dr. Phu Luong to migrate a multi–block version of the Princeton Ocean Model (POM) code for parallel execution using both MPI and OpenMP. After identification of subroutines that account of over 50% of time was done, the loops in these subroutines were analyzed. Those that took the most time were parallelized with OpenMP. In a related, but separate effort, Breshears has been investigating the possibility of using the F90 Pthreads API developed by Breshears, Gabb, and Hanson to thread the execution of entire subroutines within the POM code.

SCMICOM: Breshears has discussed the possibilities of making use of Pthreads to parallelize the SCMICOM wave model code with Dr. Matt O'Keefe (University of Minnesota) and Alan Wallcraft (NAVO). Currently, this code is parallelized on the SGI Origin2000 platform with calls to sproc. Use of Pthreads would allow the code to be more portable.

5.7.1.4 Focused Effort, Fortran Pthreads API

PET Team: R. J. Hanson, Rice, C. P. Breshears, Rice, and H. A. Gabb, CSC

Methodology: A portable Fortran module and C wrapper code was written to establish the interface. The C code is parameterized so that it is specialized for the platform and other issues. The testing package assures that the interface code is complete and passes a rigorous suite of tests.

Results: A benchmark code, provided with the test suite, establishes a rationale for use of the package to achieve efficiency in DoD application codes. The performance gains are often compelling.

Significance: The API allows the Fortran programmer the use of efficient thread technology to develop DoD applications. Any of the languages Fortran, C or C++ can be used in the development.

5.7.1.5 Focused Effort, Memory Hierarchy Simulator

PET Team: John Mellor–Crummey, Rob Fowler, Yuan Zhao, Kai Zhang, David Hilvert, Monika Mevencamp, Rice University

Methodology: Develop an integrated instrumentation tool and memory hierarchy simulator to pinpoint the causes of poor memory hierarchy utilization in Fortran programs. The instrumentation tool records information static about array references, loops, and procedures in a program and then augments the program with calls to a simulator to monitor execution behavior. The simulator mimics a multi–level memory hierarchy for a target computer system and records results associated with each source code access. Simulation results are then assembled into a collection of HTML files that form the basis of a multi–pane user interface. The interface presents results for each instrumented array access at each level of the memory hierarchy. Source code references and their results are correlated with hyperlinks so they can be explored easily.

Results: The project effort has focused on developing the Fortran 90 language support and refining how to present reference, loop and procedure–level analysis results hyperlinked to the corresponding source code in an HTML browser. A Fortran 77 version of the tool is nearly ready for distribution. A preliminary version of the Fortran 77 tool has been used to analyze a DOE discrete neutron transport code, and a finite–element analysis code developed at Rice. The tool pinpointed how non–unit stride references were causing TLB misses in the neutron transport code, and how the lack of array padding was causing multiple references to data in a single 3D array to conflict with one another in cache.

Significance: There is a substantial gap between processor and memory speeds. Modern computer systems bridge this gap with memory hierarchies that consist of multiple layers of caches. High performance requires efficient cache utilization. Most scientific codes were developed for vector processors that had no caches. When porting such applications to machines with multiple layers of caches, it is difficult to understand the reasons for poor memory hierarchy utilization. Hardware counters can identify where misses occur. The MHSIM simulator and associated instrumentation tool orchestrate a detailed simulation of multi–level memory hierarchies that can help identify the causes responsible for poor memory hierarchy utilization and help users achieve a higher fraction of peak performance.

5.7.2 Tennessee

The Tennessee Year 4 PET effort has addressed both ongoing user support and training for programming tools already deployed on ERDC MSRC platforms, as well as investigation and development of new tool capabilities for performance optimization, distributed computing, and metacomputing. The approach has been to ensure that the appropriate tools are installed and working properly on ERDC MSRC systems, to make information about installed tools available to as wide an audience as possible, and to provide one–on–one assistance to users as needed. All computational technology areas require robust easy–to–use debugging and performance analysis tools. Since many DoD users develop and run applications on multiple MSRC platforms, it is highly desirable to have the same tools available across platforms so that users receive the maximum benefit from the time spent in learning to use a tool. Because some large applications and problems require scalable computing solutions that employ multiple HPC resources simultaneously, there is a growing need for support for distributed computation and remote file access. The approach to meeting this need has been to evaluate current systems for metacomputing and parallel I/O and to extend current vendor support for parallel I/O with additional capabilities for efficient distributed access to remote files.

5.7.2.1 Scalable Parallel Programming (SPP) Tools Repository

To enable MSRC users to find out about and learn to use appropriate tools, Tennessee has continued to maintain a web–based Scalable Parallel Programming (SPP) Tools repository at http://rib.cs.utk.edu/cgi–bin/catalog.pl?rh=230. This repository contains a listing of tools being made available and/or being supported as part of our PET efforts. In addition to debugging and performance analysis tools, information is available about high performance math libraries, parallel languages and compilers, and parallel I/O systems. The repository includes a software deployment matrix that provides a concise view of which tools are installed on which platforms. By clicking on an entry for a particular tool and a particular platform, the user can access site–specific usage information and tips as well as web–based tutorials and quick–start guides. The Repository in a Box (RIB) toolkit that was used to create the SPP Tools repository is available for CTAs and other PET support areas to use to make their software and tools more accessible and useful to users.

5.7.2.2 Debuggers

Debuggers listed in the SPP Tools repository include the cross–platform TotalView multiprocess and multi–thread debugger, as well as platform–specific debuggers. Although TotalView is highly recommended, since it has excellent capabilities and is available on all ERDC MSRC platforms, information is included about platform–specific debuggers in case their special features are needed. Performance analysis tools listed include the Vampir cross–platform performance analysis tool as well as platform–specific tools. Tennessee has worked closely with ERDC MSRC systems staff to ensure that the tools are properly installed and tested on MSRC platforms and to report any bugs to the tool developers. Tennessee has participated in beta testing of new version of TotalView and Vampir.

The new 4.0 release of TotalView includes a command–line interface and improved support for OpenMP and threads programming. The new Vampir release has the capability of source–code clickback which enables users to more easily relate communication events displayed from the trace file with constructs in their source code. In collaboration with DOE ASCI, Tennessee has developed a web–based tutorial for TotalView and is currently working on web–based tutorials for Vampir and for the general topic of performance optimization.

5.7.2.3 Performance Data

For years, collecting performance data on applications programs has been an imprecise art. The user has had to rely on timers with poor resolution or granularity, imprecise empirical information on the number of operations performed in the program in question, vague information on the effects of the memory hierarchy, etc. Today hardware counters exist on every major processor platform. These counters can provide application developers valuable information about the performance of critical parts of the application and point to ways for improving the performance. Performance tool developers can use these hardware counters to develop tools and interfaces that users can insert into their applications.

The current problem facing tool developers is that access to these counters is poorly documented, unstable or unavailable to the user level program. To address this problem, Tennessee has developed the PAPI library which is a portable library for accessing hardware performance counters. The focus of the PAPI project is to provide an easy to use, common set of interfaces that will gain access to performance counters on all major processor platforms, thereby providing application developers the information they may need to tune their software on different platforms. The goal is to make it easy for users to gain access to the counters to aid in performance analysis, modeling, and tuning. PAPI reference implementations are available for the Cray T3E, SGI/Cray Origin 2000, IBM SP and SP3, and Linux Pentium clusters. Implementations are currently underway for the Sun E10000 and the Compaq ES–40. Thus all major DoD MSRC platforms will be supported in the near future. PAPI has been installed and tested at ERDC MSRC, and PAPI is being used to tune large EQM applications. Use of PAPI allows EQM code developers to quickly, easily, and accurately measure and visualize the FLOP rate, cache performance, and other interesting performance metrics for their codes. A workshop to introduce other MSRC users to PAPI is planned. For more information about the PAPI project, see http://icl.cs.utk.edu/projects/papi.

5.7.2.4 MPI Implementations

Currently different vendors' MPI implementations cannot interoperate directly with each other. Previously use of distributed MPI computing across different vendors' machines required use of a single MPI implementation, such as MPICH. This solution may be sub–optimal because it cannot utilize the vendors' optimized MPI implementations. MPI–Connect, a software package developed by Tennessee, provides the needed interoperability between different MPI implementations, or instances of the same implementation on different machines. MPI–Connect is transparent to MPI applications in that it allows intercommunication between different implementations using normal MPI communication calls.

MPI–Connect–IO is an extension to MPI–connect to handle the situation where distributed MPI applications need shared access to the same remote files. MPI–Connect–IO can be used either together with MPI–Connect or in standalone mode. When used together with MPI–Connect, MPI–Connect–IO allows distributed MPI applications to access shared files using normal MPI–2 calls. MPI–Connect–IO has been tested on Tennessee systems using together with the ROMIO MPI–2 I/O implementation. Testing on ERDC MSRC systems will commence as soon as those systems upgrade to MPI implementations that support MPI–2 IO. In addition to support for distributed MPI computations, MPI–Connect–IO will enable computational and scientific visualization components of an application to be coupled so as to allow visualization to take place during an application run rather than after. For more information about MPI–Connect–IO, see http://icl.cs.utk.edu/projects/mpi–connect/pio.html

5.7.2.5 Distributed Heterogeneous High Performance Computational Resources

Various software systems are being developed to enable distributed heterogeneous high performance computational resources to be linked together for solving large–scale application problems. Another goal is to provide users with seamless access to and ease of use of the distributed set of resources. Tennessee has been evaluating Globus, Legion, and other emerging metacomputing systems in terms of their applicability to ERDC MSRC systems and according to the following criteria:

1. Security
2. I/O capabilities
3. Language support
4. Fault tolerance
5. Scalability
6. Ease of use
7. Resource management
8. Single namespace
9. Ease of installation and maintenance
10. Extensibility
11. Systems overheads
12. Assistance and support

The evaluation results will provide data for planning an MSRC metacomputing strategy. Metacomputing has the potential to support large–scale applications running across multiple distributed machines and to increase user productivity by enabling seamless access to a variety of networked HPC resources.

5.8 SV: Scientific Visualization (NCSA–Illinois)

During Year 4, we continued an active dialog with users and ERDC MSRC visualization experts, provided information about emerging developments in graphics, visualization, and data management strategies, assisted with visualization production, and conducted a number of training sessions. We also transferred a number of specific tools to ERDC MSRC users and provided training in their use. These tools are having direct impact on these users ability to do their work.

5.8.1 CbayVisGen

A new release of the visualization tool CbayVisGen was transferred to the ERDC MSRC. CbayVisGen is a visualization tool specially designed to support the visualization needs of Dr. Carl Cerco and his EQM team. This group is investigating long–term phenomena in the Chesapeake Bay, with results being provided to the EPA. CbayVisGen used existing visualization libraries and customized a tool to visualize the hydrodynamics and nutrient transport activity over 10–year and 20–year time periods. Dr. Cerco's work has moved to full production runs, and he has frequent needs to share his results with his EPA science monitor. CbayVisGen was customized to include easy image and movie capture. These items can be easily transferred to a Web page for sharing with his colleagues. This new release also incorporates the functionality of our earlier prototype for visualizing transport flux data. Dr. Cerco had no mechanisms for viewing this part of his data, so this new release has added new and needed capability.

5.8.2 Training

We conducted both informal and formal training sessions. We presented "An Introduction to Scientific Visualization" at the Jackson State University Summer Institute. A two–day workshop on the use of HDF5 was developed and presented. A first installment of this course was aimed at ERDC MSRC staff. A second presentation, targeted at end users, was presented live at the ERDC MSRC and was webcast to the broader community.

5.9 University of Southern California: HPC Benchmarking

Matrix computations are inherent in many classes of high performance applications. In applications with large data sizes, matrix computations involve large data movement between the different levels in the memory hierarchy. This results in high memory access costs due to cache misses, TLB misses, and memory swapping, among others. In this effort we addressed two basic matrix operations: matrix transpose and matrix multiplication. Efficient techniques are developed to optimize the memory hierarchy performance for these matrix operations.

5.9.1 Efficient Algorithm for Large–Scale Matrix Transposition

Efficient transposition of large–scale matrices has been widely studied. These efforts have focused on reducing the number of I/O operations. However, in the state–of–the–art architectures, data transfer time and index computation time are also significant components of the overall time. We propose an algorithm that considers all these costs and reduces the overall execution time.

Our out–of–core matrix transpose algorithm reduces the total execution time by reducing both the number of I/O operations and the index computation time. The reduction in the number of I/O operations is achieved by using efficient data layout on disk and balancing the number of read and write operations. We analyze the complexity of our algorithm using the well–known Parallel Disk Model (PDM) and the Linear Model (LM).

Our algorithm reduces the number of I/O operations significantly by using two techniques: (1) writing the data onto disk in predefined patterns and (2) balancing the numbers of read and write operations to disk. The reduction of the number of I/O operations has a significant impact on overall time for I/O. The reason for this is that the startup time for an I/O operation is several orders of magnitude than the time for transferring an actual data byte, in state–of–the–art disk systems. The idea behind balancing the I/O operations is to reduce the number of write operations at the expense of an increased number of read operations, so that the total number of I/O operations is reduced compared with the state–of–the–art.

To eliminate the index computation cost, our algorithm partitions the available memory into two buffers (read and write buffers). The expensive in–processor permutation is replaced by collect operations. The write operations and collect operations are scheduled efficiently to reduce the overall time. The size of each buffer is determined by the available memory size and the factorization of N. By using these techniques, the index computation is replaced by inexpensive do–loops.

The experimental results on a Sun Enterprise and a DEC Alpha show that our algorithm reduces the execution time by about 50%, compared with the best known algorithms in the literature. We compare the best known algorithm in the literature with the proposed algorithm in the table below.

Table 1. Matrix Transposition time on various architectures.

(a) Results on DEC Alpha 21264

Data Size (MBytes)	Previous (Sec)	Proposed (Sec)	Speedup
128	50	24	2.08
512	248	125	1.98
2048	1031	596	1.73

(b) Results on Sun Enterprise UltraSPARC II

Data Size (MBytes)	Previous (Sec)	Proposed (Sec)	Speedup
128	36	18	2.00
512	145	80	1.81
2048	613	353	1.74

5.9.2 Efficient Matrix Multiplication Using Cache Conscious Data Layouts

A novel data layout is proposed to reduce cache pollution and data cache and TLB misses in performing “standard” matrix multiplication. To perform matrix multiplication C = A x B, the elements in Matrix B are accessed in column major order. If Matrix B is stored in a row–major order, each access to B will result in a cache miss since they belong to different cache blocks. In large–scale matrix multiplication only small portions of such cache blocks are accessed before they get replaced due to conflicts. Large matrices also result in TLB misses which significantly affect the performance.

We reorganize the layout of matrix data stored in the main memory such that it is cache friendly. This reorganization is performed prior to the computation. In the proposed data layout, we transpose matrix B so that the data layout matches the data access pattern. This reduces cache pollution. Then, we partition each matrix into square sub–matrices, denoted as blocks. In the proposed data layout, matrix elements belonging to the same block are stored in consecutive memory locations in row major order. This avoids conflict misses among the elements in the same block. The block size is chosen to be equal to the virtual page size. This ensures that computations within a block will not result in a TLB miss.

We have implemented our scheme on UltraSPARC II, Alpha 21264, and Pentium III based machines for matrix sizes ranging from 1024x1024 to 1536x1536. Table 1 compares the performance of our scheme with the naive CBLAS (without blocking), CBLAS (with blocking), and CBLAS (with blocking and copying) algorithms. The reported execution times are wall clock time. On UltraSPARC II, Alpha 21264, and Pentium III machines, we used the gcc compiler with ’–O3’ optimization option. As shown in Table 1, our scheme is up to 15 times faster than naive CBLAS, 2 times faster than blocking based CBLAS, and is 22% faster compared to blocking and copying based CBLAS implementation on UltraSPARC II. On Alpha 21264, our scheme performs up to 5 times faster than the naive CBLAS, up to 3 times faster than blocking based CBLAS, and is 23% faster than blocking and copying based CBLAS implementation. On Pentium III, our scheme outperforms all the three previous techniques.

Table 2. Execution time on various platforms in seconds

(a) UltraSPARC II (400MHz, 2MByte L2 cache)

Matrix Size	CBLAS (Naive)	CBLAS (Blocking)	CBLAS (Blocking + Copying)	Our Method
1024 x 1024	243.418	34.147	22.271	17.240
1200 x 1200	370.387	40.663	34.478	29.920
1280 x 1280	455.795	65.952	42.262	33.842
1400 x 1400	592.934	66.675	53.522	45.192
1536 x 1536	810.280	124.489	74.740	60.865

(b) DEC Alpha 21264 (500MHz, 4MByte L2 cache)

Matrix Size	CBLAS (Naive)	CBLAS (Blocking)	CBLAS (Blocking + Copying)	Our Method
1024 x 1024	125.237	23.214	16.427	13.283
1200 x 1200	194.556	28.330	28.465	22.383
1280 x 1280	238.613	31.115	29.984	26.503
1400 x 1400	310.947	44.730	45.311	35.248
1536 x 1536	415.870	79.907	54.045	45.816

(c) Pentium III (450MHz, 512KByte L2 cache)

Matrix Size	CBLAS (Naive)	CBLAS (Blocking)	CBLAS (Blocking + Copying)	Our Method
1024 x 1024	92.566	27.136	22.030	17.335
1200 x 1200	152.311	30.107	33.390	28.050
1280 x 1280	184.973	52.325	43.117	34.184
1400 x 1400	244.652	48.215	55.644	45.756
1536 x 1536	325.241	90.306	74.345	59.137

6. Tools Introduced into ERDC MSRC

The enhancement of the programming environment at ERDC MSRC through the identification and introduction of programming tools, computational tools, visualization tools, and collaboration/communication tools is a major emphasis of the ERDC MSRC PET effort. Tools introduced into ERDC MSRC by the PET team during Year 4 are listed in Table 4. Other tools installed in previous years are described in earlier reports and are continually supported. The ERDC MSRC PET team has provided training courses at the ERDC MSRC and at remote user sites for many of these tools (see Section 7), and continually provides guidance and assistance in their use through the on–site team. The purpose of this present section is to discuss the function of these tools and their importance to ERDC MSRC users. Many of these tools came from collaborative efforts across various components of the ERDC MSRC PET team, both on–site and at the universities.

6.1 Programming Tools

6.1.1 TotalView 4.0

Tennessee (UTK) assisted with beta testing of the new release of TotalView that includes a command–line interface and support for threads and OpenMP programmming. UTK participated in the High Performance Debugging Forum that developed the standard for a parallel command–line debugging interface that has been adopted by TotalView. UTK has extended a web–based tutorial developed for DOE ASCI with versions of the exercises for ERDC MSRC platforms and with instructions on how to use the command–line interface. UTK has made suggestions about how better support for threads and OpenMP might be provided in the next release of TotalView.

The TotalView command–line interface will allow remote MSRC users to make more effective use of TotalView. TotalView support for threads and OpenMP and for mixed OpenMP and MPI programming, in addition to previously available support for MPI, means that the same debugger interface can be used for all parallel programming models.

6.1.2 Vampir 2.0

UTK assisted with beta testing the new release of Vampir and is developing a web–based tutorial on Vampir in collaboration with DOE ASCI.

The new version of Vampir includes support for source–code clickback that enables users to more easily correlate communication events with constructs in their source code. Vampir developers plan to incorporate OpenMP support into the next releas of Vampir and to support mixed MPI and OpenMP programmming, thus allowing MSRC users to analyze and tune performance for all parallel programming models using the same interface on all ERDC MSRC platforms.

6.1.3 MPI–Connect–I0

MPI–Connect is a software package developed at UTK that provides interoperability between different MPI implementations. MPI–Connect–IO is an extension to MPI–Connect to handle the situation where distributed MPI applications need shared access to the same remote files. MPI–

Connect–IO has been tested on UTK systems using ROMIO and will be tested with vendor versions of MPI–2 Parallel I/O as soon as these are available on ERDC MSRC systems.

Use of MPI–Connect–IO, either standalone or together with MPI–Connect, will enable MSRC users to simultaneously access shared files from distributed components of an application. An MPI–Connect–IO driver for HDF5 (planned for Year 5) will provide remote file access support for users of HDF5.

6.1.4 PAPI

UTK has specified a standard interface and set of performance metrics for accessing hardware performance counters on multiple high performance computing platforms. UTK has produced reference implementations of PAPI for ERDC MSRC platforms and has produced a graphical tool called the perfometer that provides a runtime trace of a selected PAPI metric.

The PAPI portable interface to hardware performance counters will enable users to use the same set of routines to access comparable performance data across platforms. Hardware performance counters can provide valuable information for tuning the cache and memory performance of applications. PAPI will also enable CHSSI code developers to more quickly and easily obtain data needed for performance reporting requirements. The perfometer tool provides a quick and easy way for developers to assess the performance of their applications.

6.1.5 dyninst

University of Maryland has produced the dyninst library which provides an API for attaching to an instrumenting an executable running on a single processor. UTK has provided a package for the SGI/Cray Origin 2000 that includes dyninst and a UTK–developed extension of dyninst to parallel and distributed environments called the Free Probe Class Server (FPCS).

The dyninst library will enable users to attach to a running application and monitor or even change application behavior dynamically. FPCS allows dyninst to control parallel tasks so that users can instrument all tasks with a single command.

6.1.6 ScaLAPACK

Parallel linear algebra library. This library, along with the BLACS (Basic Linear Algebra Communication Subroutines), is available on all ERDC MSRC HPC platforms.

6.1.7 SuperLU

Sparse, direct solver library. Breshears built and installed updated versions of the SuperLU sparse direct solver libraries on the appropriate ERDC MSRC HPC platforms.

6.2 Visualization Tools

6.2.1 CbayVisGen

In Year 4, the PET visualization team transferred a new and enhanced release of the visualization tool CbayVisGen to the MSRC. CbayVisGen was specially designed to support the visualization and collaboration needs of Dr. Carl Cerco and his EQM team. The tool enables them to visualize the hydrodynamics and nutrient transport activity over 10–year and 20–year time periods of activity in the Chesapeake Bay. This new release now incorporates alternatives for visualizing the transport flux data. Dr. Cerco had no mechanisms for viewing this part of his data, so this tool has added new and needed capability.

6.2.2 Tecplot

The Tecplot scientific visualization software package has been introduced to ERDC MSRC. The package allows flexible, interactive generation of high quality plots and animations and is widely used by and well suited for the CWO scientific community. Dr. Stephen Wornom of OSU has used Tecplot in the preparation of PET CWO presentation materials and reports, and also for the informal distribution of ongoing research findings to the ERDC CHL wave modeling group. The package has been installed in the ITL Visualization Laboratory and can be accessed by all HPC users. A nice feature of the Tecplot software is that graphics can be published directly in the HTML format which permits interaction by users at different sites.

6.3 Communication/Collaboration Tools

6.3.1 Tango Interactive

Tango Interactive is a Java–based web collaboratory developed by NPAC at Syracuse University (with initial funding from AF Rome Lab). It is implemented with standard Internet technologies and protocols, and runs inside an ordinary Netscape or Internet Explorer (in testing) browser window. Tango delivers real–time multimedia content in an authentic two–way interactive format. Tango was originally designed to suppport collaborative workgroups, though synchronous distance education and training, which can be thought of as a highly structured kind of collaboration, had become one of the key application areas of the system.

The primary Tango window is called the Control Application (CA). From the CA, participants have access to many tools, including:

- SharedBrowser, a special–purpose web browser window that “pushes” web documents onto remote client workstations.
- Whiteboard, for interactive text and graphics display.
- Several different kinds of chat tools.
- BuenaVista, for two–way audio/video conferencing.

Tango has been deployed for some time at the ERDC MSRC and at Jackson State University for use in joint Syracuse–Jackson State distance education work begun in Year 2. More recently, Tango Interactive has been used to deliver PET training through installations at all four of the MSRCs and other sites as well.

During Year 4, a substantial investment has been made in the Tango Interactive system to improve its user interface, increase security, and expand functionality towards a “virtual community” model. These efforts resulted in the release of Tango Interactive 2.0 in January 2000, with additional improvements in version 2.1 at the end of Year 4.

6.4 Computational Tools

6.4.1 CTH and EPIC

Several software modules and programming tools have been developed or upgraded in support of the activity. These include:

1. Software modules for error indicator computation in CTH .
2. Software modules for shape quality and error indicator computation in EPIC.
3. Software to incorporate block refinement in parallel simulations for CTH (jointly with D. Crawford, Sandia).
4. Software for partitioning unstructured grids using Space–Filling Curves.
5. The TESTBED for evaluating error indicators and algorithms in Adaptive Refinement.
6. Software modules in CTH for material interface tracking in 2:1 block refinement.

Some of the software modules for error indicators are more broadly applicable (with perhaps minor modification) to other PET program analysis components. The software for adaptive refinement and data structure modification is more specific to the application codes in question but the concepts are general. The module for ordering cells and partitioning based on space–filling curves is written in C++ and has quite general applicability. The TESTBED approach can be applied to other applications and codes with differing physics. It is being tested with a scalar transport physics and will be shortly extended to hyperbolic systems with shocks. The integrated effect of these developments on the MSRC is significant since it will provide a new adaptive analysis capability and spearhead similar extensions to the DoD application codes both in CSM and the other PET areas.

6.4.2 UTPROJ, KeLP

The EQM team is using KeLP to provide the Message Passing Interface for the parallel version of UTPROJ. KeLP is a portable programming tool which provides data structures and calls for message passing in MPI codes. It was developed by Scott Baden, et al, at the University of California at San Diego under the NPACI project. The purpose of KeLP is to reduce the time for migrating serial codes into a message–passing environment.

6.4.3 WebHLA

WebHLA is a collection of tools, packaged as HLA federates and used for integrating Web/Commodity based, HLA compliant and HPC enabled distributed applications. WebHLA tools/federates which have been installed at ERDC MSRC include:

- JWORB (Java Web Object Request Broker) — a universal middleware server written in Java that integrates HTTP, IIOP and DCE RPC protocols i.e. it can act simultaneously as Web Server, CORBA broker and DCOM server.
- OWRTI (Object Web RTI) — a Java CORBA implementation of DMSO RTI 1.3, packaged as JWORB service and used as a general purpose federation and collaboration layer of the WebHLA framework.

6.4.4 WCBL

The WCBL combined wave/current/sediment boundary layer model has been written and deployed. The code permits the coupling of wave, circulation, and sediment transport models at the marine bottom boundary layer. The code simulates the nonlinear interaction of wave and current boundary layers and accounts for suspended sediment–induced stratification. The code has been coupled with the CH3D–SED circulation/sediment tranport model and the WAM wind–wave model, with the parallel–processing, coupled system deployed for the Adriatic Sea. The improved boundary layer representation provides the circulation, sediment, and wave models with more accurate boundary layer parameters such as roughness height and friction factor. WCBL is at present being tested and refined to insure appropriate convergence for the range of possible wave/current/sediment regimes.

7. User Training

Since its inception, the ERDC MSRC PET training program has faced two challenges. One is to provide training in an anytime, anypace, anyplace environment. That goal has not been reached, but the PET program has continued to support efforts in remote training and distance education. Those efforts are now bearing fruit as can be seen from this report. The second challenge is to meet the needs of ERDC MSRC users faced with a rapid change in available hardware and software systems.

7.1 Training Curriculum

PET training is designed to assist the ERDC MSRC user in transitioning to new programming environments and efficiently using the present and future SPP (Scalable Parallel Processing) hardware acquired under the HPCMP program. The training curriculum is a living document with new topics being added continually to keep up with the fast pace of research and development in the field of HPC. The curriculum contains courses in the following general categories:

- Parallel programming
- Architecture and software specific topics
- Visualization and performance
- CTA targeted courses, workshops, and forums

Table 7 gives a list of all training courses taught during Year 4 with the organization offering the course, the number of students attending the course. (The location is listed in the table.)

7.2 Web–Based Training

During Year 4, three distance education courses were conducted over the Web. Syracuse delivered two graduate courses (Topics in Networking and Multimedia Applications, and Advanced Web Technologies) to Jackson State, Clark Atlanta, and Morgan State. Syracuse delivered the course Computational Science for Simulation Applications to the ERDC Graduate Institute. The course was also received by Morgan State, Jackson State, NAVO, and NRL–DC. Syracuse also delivered the Advanced Web Technologies course to Mississippi State. All these offerings were full semester, for–credit (at the local university) courses delivered over the Web using the Tango collaborative software environment.

7.3 Training Course Descriptions

This material appears on the ERDC MSRC PET Website as training course descriptions in advance of courses, http://www.wes.hpc.mil/

8. Support of ERDC MSRC Users

Since the great majority of users of the ERDC MSRC are off–site, the ERDC MSRC PET effort places emphasis on outreach to remote users, as well as to users located on–site at ERDC. Table 3 lists the contacts made with ERDC MSRC users by the ERDC MSRC PET team during Year 4, and Table 2 lists all travel by the ERDC MSRC PET team in connection with the Year 4 effort. A major component of outreach to ERDC MSRC users is the training courses (described in Section 7) conducted by the ERDC MSRC PET team, some of which are conducted at remote user sites and some of which are web–based. The ERDC MSRC PET website, accessible from the ERDC MSRC website, is also a major medium for outreach to ERDC MSRC users, and all material from the training courses is posted on the PET website. A CD–ROM of training material has also been prepared.

Specific support activities conducted in Year 4 are described in this section, which is organized by individual components of the ERDC MSRC PET effort.

8.1 CFD: Computational Fluid Dynamics CTA (ERC – Mississippi State)

As part of the Core Support, the CFD team was able to provide training, user support, outreach and technology transfer via participation in a workshop on CHSSI software overview, short courses on CFD and grid generation, seminars at JSU and Morgan State University, a short course and a poster session at the 8th International Meshing Roundtable, and direct ERDC MSRC user contacts.

Interactions with ERDC MSRC users have been initiated by a variety of means. Telephone, e–mail, and personal visits have all resulted in opportunities for user support, collaborative efforts, training needs, and technology issues. Long discussions were held with various users and Dr. Jay Boris, DoD CFD CTA lead during the DoD HPC User's group meeting. A presentation on CFD CTA PET program overview was made at the DoD HPC User's group meeting.

The workshop at the AIAA Aerospace Sciences meeting was an excellent vehicle for user outreach and technology transfer. The CFD team has provided support (visualization, parallel processing, queueing and allocation) to OVERFLOW_D (Dr. Robert Meakin), WIND (Dr. Jerry Metty) and FAST3D (Dr. Sandy Lanceberg) CHSSI development teams. An overview of CFD CHSSI software was published in the CFD News Letter. The feature detection algorithm developed at MSU was transferred to Dr. Ravi Ramamurti (NRL) and Dr. Tai (David Taylor Navy center). Assistance with the execution and utilization of the code were provided.

8.2 CSM: Computational Structural Mechanics CTA (TICAM – Texas, with ERC – Mississippi State)

The first step in outreach was preparation of the report from the workshop, held in Austin, on Adaptive grids and Related Technology in which ERDC, DoE, Texas and other researchers participated. Rick Weed, the CSM On–Site Lead, has been instrumental in coordinating our interactions with the applications analysts at ERDC MSRC and elsewhere, and the Jackson State Workshop which he co–taught with David Littlefield. Sessions were organized by Graham Carey and David Littlefield at the DoD HPC Users Group meeting in Monterey at mid–year and at the SES meeting in Austin in the fall.

A Workshop on Unstructured and Adaptive Grids was held at ERDC MSRC by Graham Carey, and a subsequent seminar mini–course by Tinsley Oden also at ERDC MSRC. Follow up with the users at ERDC Structures Lab was made prior to the PET Annual Review Meeting in February 2000 by G. Carey, J.T. Oden, and D. Littlefield, coordinated by R. Weed. This included presentations by both the Structures Lab users and by the Texas participants. As a result of this meeting we mapped out further guidelines and problem areas for our continued work in support of their applications needs. David Littlefield has been working closely with the Sandia applications software group (D. Crawford, G. Hertel) and has also been in regular close contact with the major ARL users (K. Kimsey, D. Scheffler, D. Kleponis).

We have had several discussions with Raju Namburu, both at ERDC and more recently at ARL, and recently discussed tech transfer to transition the adaptive CTH code version to the DoD users. This transfer is being coordinated with Gene Hertel and the Sandia group. Graham Carey has been interacting with Rob Leland's group on grid partitioning, grid quality, and parallel partitioning issues. The group is applying the CHACO software at UT and has arranged to obtain the grid generator software CUBIT for continuing studies. We plan to follow up then with dynamic partitioning studies later in the program. In the area of user outreach, the major accomplishments for the CSM On–Site Lead, Weed, were the support for ERDC Structures Lab funded work to develop a parallel version of the EPIC code and cross–CTA support for on–going CHSSI project (EQM 1) work being performed by the ERDC Coastal Hydraulics Lab. The work with the EPIC program provided a starting point for Alliant Systems personnel in their development of a full parallel version of EPIC. The software developed to support the CHSSI project allowed ERDC researchers to replace NASA–developed software that was difficult to maintain across all the parallel platforms at ERDC MSRC with simpler and more easily maintained software. This helped the CHSSI code developers meet critical deadlines.

8.3 CWO: Climate/Weather/Ocean Modeling CTA (Ohio State)

The Ohio State University CWO team continues to interact with and reach out to ERDC MSRC users in a wide variety of ways. The major interactions can generally be classified as on–site planning meetings, training classes, and seminars. Between these events, there is ongoing communication in the form of e–mails, telephone calls, and informal meetings. Major contacts with users typically involve all four senior OSU team members: Professors Keith Bedford and Ponnuswamy Sadayappan, CWO On–Site Lead Dr. Stephen Wornom, and Senior Research Associate Dr. David Welsh.

There were three major planning meetings between the OSU team and ERDC CHL scientists in the past project year. One meeting was with Dr. Jeff Holland's group to plan parallelization efforts on sigma– and z–plane versions of the CH3D–SED model. The OSU group took on the beta–testing role for these coding efforts. Two planning meetings were held with the CHL wave modeling group, including Drs. Don Resio, Jane Smith, Bob Jensen, and Zeki Demirbilek. The purpose of these meetings were to coordinate PET CWO efforts with the CHL group's overall wave modeling strategic plan. These meetings involved reporting of OSU's recent work and discussion of future collaborations, in particular PET Focused Effort proposals.

The training classes offered by OSU have permitted the techniques and results of PET research to be presented in detail to ERDC MSRC users. This has led to significant interest in the coupled wave/current/sediment modeling system being developed by OSU using the WAM, CH3D–SED, and WCBL models. In particular, Dr. Joe Gailani of ERDC CHL and Dr. Peter Orlin of NAVO are interested in using the system to provide numerical modeling support for their coastal and riverine sediment plume projects, respectively. A training class contact also led to Dr. Michael Brooking of NAVO facilitating access to Adriatic Sea data for the verification of PET CWO research.

PET CWO research seminars have also been presented in the last project year at NAVO/NRL–Stennis, and NRL–Monterey/FNMOC. The purpose of these presentations was to reach out to scientists who play vital roles in the CWO activities of the DoD as a whole. Some of these scientists are present or potential ERDC MSRC users, while others have important working relationships with ERDC CHL staff. As a result of the visit to NRL–Monterey, Dr. Richard Hodur provided COAMPS model wind fields for use in Adriatic Sea simulations.

The daily interactions of ERDC MSRC users and CWO On–Site Lead, Dr. Stephen Wornom, have resulted in significant collaboration. Dr. Wornom has carried out an evaluation of the SWAN model and WAM/SWAN interface with the help of Dr. Robert Jensen. As part of this effort, Drs. Wornom and Jensen arranged the visit to ERDC of Dr. Ijsbrand Haagsma, a leading member of the SWAN development group at the Delft University of Technology. Dr. Wornom also worked with Dr. Lori Hadley of ERDC CHL on SWAN deployment, and provided input on the parallelization of STWAVE to the CHL waves group. Dr. Wornom has also arranged a series of meetings between ERDC PET staff and ERDC MSRC users, including Dr. Alan Wallcraft of NRL–Stennis, who are interested in the implementation of the POSIX Threads portable, multi– processing library in the MICOM ocean model. As a result, Dr. Wornom will be take the lead on this task in the upcoming project year.

8.4 EQM: Environmental Quality Modeling CTA (TICAM – Texas)

Mary Wheeler, Clint Dawson, Victor Parr and Phu Luong met with Jeff Holland, Charlie Berger, Bob Bernard, Fred Tracy, Stacy Howington and Rao Vemulokanda of ERDC in June of 1999 to discuss the current status of our focused effort on the projection code UTPROJ, and to discuss future plans. Based on these conversations we decided to focus on connecting UTPROJ with TABS–MDS for demonstration purposes. During this visit, Parr also performed one–on–one training with Rao Vemulakonda about the latest versions of ADCIRC, CE–QUAL–ICM, and UTPROJ.

Parr then worked with Gary Brown of ERDC over the summer and fall to build appropriate test cases for the UTPROJ/TABS–MDS demonstration. He visited Charlie Berger and Gary Brown to demo a prototype version of UTPROJ, discussed how to include proper boundary conditions, and jointly developed a method for handling time–dependent mass–balance errors.

Luong also met with Berger and Brown to discuss the use of the SuperLU library for performance improvement of the TABS–MDS code. The performance of the code with the new library was not overly encouraging, however.

In October 1999, Dawson discussed the current status of the projection code UTPROJ with Carl Cerco of ERDC. They discussed the connection of this code to CE–QUAL–ICM. Based on these and other discussions with ERDC personnel, future efforts will involve projecting hydrodynamics data from any grid onto any given transport grid.

After their workshop on flow and reactive transport algorithms, held at ERDC in September, Wheeler and Dawson discussed with Charlie Berger and Stacy Howington of ERDC the use of discontinuous Galerkin methods for flow and transport in the ADH code. It was agreed that further study of the methods was needed but the methods were of potential use.

Luong met with Ron Heath and Billy Johnson of ERDC in September 1999 to discuss replacing the ADI solver in the CH3D–Z code. As a result of these discussions we obtained funding after the midyear review for a focused effort on putting a conjugate gradient solver into CH3D–Z. This has been accomplished.

In October 1999, Luong met with Bob Bernard of ERDC to discuss making the CH3D code into a multiblock code for improving performance of the CH3D–SIGMA code. He also met with Rao Vemulakouda of ERDC to discuss using OpenMP in the ADCIRC code. No actions have been taken as a result of these discussions.

Luong met with Barry Bunch, Carl Cerco and Mark Dortch of ERDC to discuss improving the performance of CE–QUAL–ICM and CE–QUAL–ICM/TOXI. The discussion was about using VAMPIR and SpeedShop to detect the long execution time loops in the code, then using OpenMP directives around these loops to speed up the execution time. Parr has recently used VAMPIR to detect bottlenecks in the message passing in CE–QUAL–ICM. Based on these results, Parr visited with Carl Cerco, Barry Bunch, and Mark Noel of ERDC to discuss plans for improving the scalability of CE–QUAL–ICM. They also discussed how the projection code UTPROJ will fit into their work to link TABS–MDS and CE–QUAL–ICM.

Luong and Wheeler visited NAVO in March 2000 and gave presentations on PET related work. They met with Dr. Donald Durham who is the Technical Director of Naval Meteorology and Oceanographic Command, and discussed issues concerning CWO and EQM at NAVO PET. They visited with James Rigney and John Blaha about using parallel ADCIRC and multiblock grids with MPI/OpenMP techniques for the Northen Gulf of Mexico Littoral Initiatives Project. They also met with Steve Adamec who is the NAVO MSRC Director, and discussed issues concerning future involvement of UT Austin in the NAVO EQM PET Program.

8.5 FMS: Forces Modeling and Simulation/C4I CTA (NPAC – Syracuse)

Currently, our main DoD user group that provides the application focus and testbed for the WebHLA framework is the Night Vision Lab at Ft. Belvoir which develops CMS as part of their R&D in the area of countermine engineering. Our support for CMS includes:

- Building Parallel CMS module by porting sequential CMS to Origin2000
- Integrating Parallel CMS module with other WebHLA federates towards Metacomputing CMS Federation.

We are also interacting closely with and provide PET support for the current FMS CHSSI projects, including:

- FMS–3 where we are builing Web based interactive training for the SPEEDES simulation kernel and we are acting as external technical reviewer of Parallel Navy Simulation System;
- FMS–4 where we are acting as external technical reviewer for the beta beta release of Parallel IMPORT;
- FMS–5 where we were invited to directly participate and to provide our Object Web RTI as a test implementation of the RTI 1.3 standard, to be certified by DMSO and used by FMS–5 as a fully compliant reference prototype.

8.6 C/C: Collaboration and Communications (NPAC – Syracuse)

Since our primary effort this year focused on the Tango Interactive electronic collaboration system for use in education and training our outreach efforts focused on enlarging the base of knowlegable and experienced users of the system as a base to help support broader deployment of the tools. We conducted tutorials on Tango Interactive and its use in distance training and education at the DoD HPC User Group Conference in Monterey, CA, as well as a workshop on Distance Training at the ERDC MSRC and one on Distance Education at Jackson State University. We also conducted a training class in Syracuse in conjunction with the release of Tango Interactive 2.0 aimed at on–site support staff. We also presented a tutorial on Java at the DoD HPC User Group Conference.

Tango Interactive itself has been used to help reach out to additional users as well. Syracuse's Geoffrey Fox presented a seminar to all four MSRCs using Tango, and PET partners Ohio Supercomputer Center and National Center for Supercomputer Applications used Tango Interactive to offer a total of four PET training events to a wider audience. In addition, Syracuse offered two semester–long academic credit classes to a combination of DoD and academic sites, including all four MSRCs and the Naval Research Lab Distributed Center, Jackson State University, Mississippi State University, and Morgan State University.

8.7 SPP Tools: Scalable Parallel Programming Tools (Rice and Tennessee)

Tennessee has been in contact with Robert Maier about use of MPI–2 Parallel I/O to improve performance of the Contaminant Dispersion challenge code.

Tennessee has helped keep the SPP Tools repository at http://www.nhse.org/rib/repositories/ERDC_spp_tools/catalog/ up to date. This repository lists programming tools being made available and/or supported as part of ERDC MSRC PET efforts. The tools include parallel debuggers, performance analyzers, compilers and language analyzers, math libraries, and parallel I/O systems. In addition to giving information about the available tools, the repository includes a concise matrix view of what tools are available on what platforms with links to site–specific usage information and tips and web–based tutorials. Tennessee has tested the installed versions of the tools and has worked with ERDC MSRC systems staff to ensure that the tools are working correctly in the programming environments used by ERDC MSRC users, including the PBS queuing system, and has reported any bugs discovered to the tool developers and followed up on getting them fixed.

A CWO–related tutorial and materials were delivered to ERDC MSRC employees and contractors Jane Smith, Ann Sherlock, Steve Wornom, and Lori Hadley. Instructor for the tutorial was Richard Hanson of Rice University. The tutorials were given on April 21–23, 1999, at Rice University, with five sessions over 2.5 days. Each session was concerned with the application codes STWAVE and SWAN. The first session dealt with conversion to Fortran 90. The second and third sessions identified the parallelism in the STWAVE code and how to exploit this with message passing methods. The fourth session dealt with a required root solving method, mathematical software, memory hierarchy efficiency, project planning, and regression testing. The last session concerned actual edits to the code. Comments were inserted into the code pertaining to upgrades or changes required. The slides and edited codes were provided to the participants.

Clay Breshears worked with Ann Sherlock to begin performance analysis of the STWAVE code. In addtion, plans for migrating the serial code to a parallel distributed version were outlined. Richard Hanson analyzed STWAVE and found that a big part of the time was spent in certain elementary functions. Ann Sherlock and Jane Smith were notified of this and the findings documented in a technical report.

8.8 SV: Scientific Visualization (NCSA – Illinois)

During Year 4, the PET visualization team worked with users, the PET on–site staff for each CTA, and the ERDC MSRC visualization staff. Early in the year, we worked with on–site staff to update the long–term plan for scientific visualization. This involved communication with both visualization specialists and the on–site CTA leads.

In a long–term collaboration, the PET Visualization team worked extensively with Dr. Carl Cerco, Mark Dortch, and Mark Noel of ERDC, in relation to their Chesapeake Bay project and visual analysis of the output of the ERDC CE–QUAL–ICM code. This year, we provided a production–quality version of a tool that they are currently using to view data from their 10– and 20–year productions run of the Chesapeake Bay model. This tool also supports a limited form of collaboration that they are using to share their results with their project monitor at the Environmental Protection Agency.

In Year 4, we also had numerous contacts with ERDC MSRC visualization personnel, including Dr. Michael Stephens, Dr. Richard Strelitz, Dr. Kent Eschenberg, Richard Walters, and John West. We have advised on new software packages and techniques for visualization and virtual environments.

9. HBCU/MI Enhancement Program

For Year 4 of the PET component of the DoD HPCMP, the Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) team consisted of Jackson State University (JSU), Clark Atlanta University, and Texas A&M–Kingsville. Dr. Willie Brown of Jackson State is the overall HBCU/MI Senior Academic Leader for ERDC MSRC PET.

This section describes how these institutions participated in PET initiatives at the ERDC MSRC during the fourth year of the program, and how the institutions were enhanced by their involvement. Training courses and seminars conducted by the ERDC MSRC PET team at HBCU/MIs are listed in Table 8.

As the lead university at the ERDC MSRC, JSU is charged with developing and implementing strategies that allow a two–way exchange between the DoD and HBCU/MI communities. On the one hand, minorities are tremendously underrepresented in the Computational Technology Areas (CTAs) and other HPC efforts within the DoD. On the other hand, the existing pool of talent available to address current and future DoD challenges, using HPC technologies, is limited and decreasing. The PET program provides the DoD with an opportunity to identify and develop new sources of scientific, high–tech, and management personnel. In the opposite direction, PET affords faculty, staff, and students, at HBCU/MIs, an opportunity to acquire scientific and HPC related skills and expertise through interaction with DoD scientists and researchers. JSU's mission is to maximize mutual benefit for both sides by helping to create and maintain pathways between the ERDC MSRC and the HBCU/MI team. However, adequate access to HPC facilities, and other information technology resources, is critical to HBCU/MI participation in this endeavor.

9.1 PET Team at Jackson State

During Year 4, the JSU support team for the ERDC MSRC changed dramatically. In fact, with the exception of Dr. Willie Brown, the overall project leader, there was a complete turnover of personnel. The new team consists of four members. Dr. Brown is responsible for overall management of PET activities at JSU, including core support and focused efforts. Brenda Rascoe serves as administrative assistant for the project. She is responsible for bookkeeping, travel arrangements, and clerical support of all other JSU personnel. Chuck Patrick provides scientific visualization support for ERDC MSRC personnel and scientific visualization training for JSU students, faculty, and staff. Timothy Ward is the JSU Network Training Lead. He is responsible for technical support of the JSU Distance Education effort. This includes hardware/software set–up and maintenance, as well as classroom teaching assistance.

JSU's role in PET is two–fold. First, JSU is the lead Historically Black College/University (HBCU). In this role, JSU's primary mission is to identify, and make available to the ERDC MSRC high performance computing (HPC) capabilities and expertise at targeted HBCUs and other Minority Serving Institutions (MIs). The co–mission is to identify, and make available to those targeted HBCU/MIs opportunities for HPC training and capability development/enhancement. The second JSU PET role is strictly technical. Two Focused Efforts are in operation: distance education and scientific visualization.

In support of its HBCU/MI missions, JSU continued communication and collaboration with other PET HBCU/MIs (Central State University, Clark Atlanta University, Dillard University, and Morgan State University). In addition, JSU hosted the third annual Introductory High Performance Computing Summer Institute June 14–25, 1999. At the institute, presenters from seven ERDC MSRC PET Team Universities introduced twenty students, from six HBCUs, to HPC in general, and to the computational technology areas (CTAs) supported at the ERDC MSRC. PET Universities represented were Illinois (NCSA), Mississippi State (ERC), Ohio State (OSC), Rice (CRPC), Syracuse (NPAC), Texas (TICAM), and JSU. Students came from Alcorn State, Bethune–Cookman, Dillard, Howard, Langston, Lincoln, Southern, Tennessee State, and JSU.

During Year 4, JSU and Syracuse University continued to present distance education courses over the Web. Syracuse delivered two graduate courses (Topics in Networking and Multimedia Applications; Advanced Web Technologies) to JSU and other sites, including Morgan State, Clark Atlanta, Mississippi State, and the ERDC MSRC. All offerings were full semester, for–credit courses delivered over the Web using the Tango collaborative software environment. The JSU/Syracuse communications link was implemented on the Defense Research and Engineering Network (DREN).

Within its Scientific Visualization effort, JSU provided support for an ERDC MSRC terrain–mapping project. The objectives of the project were to 1) construct a terrain map to visualize command, control, communication and intelligence (C3I) benchmarks, and 2) develop a terrain mask visualization. Terrain masking is a process to determine whether a location or altitude is visible from different vantage points. One expected result is a terrain map that exposes defined and/or undefined C3I benchmark locations with various threat areas, or other areas of interest. A threat area can be an obscure area or an area masked by intervening terrain. Threat areas may or may not overlap.

Threaded 2–D fast Fourier transformations (FFT) were developed to test the efficacy of the map–image correlation of C3I benchmarks. Threads are designed to express task–level or functional concurrency. The purpose was to create a 2–D FFT in which the smallest functional unit is mapped to threads. Detailed analysis and evaluation of various structures are used to change thread format and threat conditions.

9.2 PET Team at Clark Atlanta

Army scientists are interested in applying our highly scaleable parallel multi–fluid finite element flow solver to complex problems including wave interactions with marine vessels in motion. Army scientists are also interest in using this technology in modeling breaking waves, a capability that does not exist with current methods. Prior to these applications, code verification becomes an issue. Although we have measured, to some degree, the accuracy of our flow solver for simple 2D problems, we never had a chance to test its accuracy for complex 3D problems. In this effort we apply our flow solver to a 3D test problem. The problem selected for code verification is circular–arc contraction. In this test problem, a high–velocity water flow in open channel is contracted with prescribed geometry. Here we will evaluate the accuracy of our flow solver at supercritical condition for an initial Froude number of 4. The comparison will be made between computed wave elevations and the experimental data.

We obtained the geometry of our test problem and the experimental data for simulation and verification. We wrote a special mesh generator subroutine to create finite element meshes for the problem. A special parallel subroutine is developed to impose the hydrostatic pressure at out flow. We successfully simulated wave formation and wave interaction in open channels at supercritical conditions. We carried out extensive parallel simulations on the CRAY T3E and IBM SP2. The results compare very well with the experimental data.

Educational Aspect: Dr. Aliabadi trained two undergraduate students at Clark Atlanta University:

1. Bruce Zellars, Male, African American, Engineering (Mechanical) at CAU.
2. Ade Abatan, Female, African American, Engineering (Chemical) at CAU.

10. List of ERDC MSRC PET Technical Reports

00–30 “HLA Integration for HPC Applications Applied to CMS,” Wojtek Furmanski, David Bernholdt and Geoffrey Fox

00–29 “Enforcing Scalability of Parallel Comprehensive Mine Simulator (CMS),” Wojtek Furmanski, David Bernholdt and Geoffrey Fox

00–28 “Web Interfaces for Environmental Modeling Systems: A WebFlow Application,” Tomasz Haupt

00–27 “Portals for Web Based Education and Computational Science,” Geoffrey C. Fox

00–26 “Reflections on Three Years of Network–Based Distance Education,” David E. Bernholdt, Geoffrey C. Fox, Nancy J. McCracken, Roman Markowski and Marek Podgorny

00–25 “Tools for Handheld Supercomputing: an Assessment of the Wireless Application Protocol (WAP),” David E. Bernholdt, Sangyoon Oh, Konrad Olszewski and Geoffrey C. Fox

00–24 “Modifications of the External Mode Solver in CH3D–Z,” Clint Dawson, Dharhas Potina and Mary F. Wheeler

00–23 “Development of Parallel 3D Locally Conservative Projection Codes for Reduction of Local Mass Errors in Hydrodynamic Velocity Field Data,” Mary F. Wheeler, Clint Dawson , Victor J. Parr and Jichun Li

00–22 “Parallel Software Tools and the Parallel Performance of the CE–QUAL–ICM Water Quality Simulator,” Mary F. Wheeler and Victor J. Parr

00–21 “Contract Year Five Programming Environment and Training (PET) Core Support and Focused Efforts”

00–20 “A Parallel–Processing Coupled Wave/Current/Sediment Transport Model,” David J.S. Welsh, Keith W. Bedford, Rong Wang and Ponnuswamy Sadayappan

00–19 “HPC Training Courses at ERDC MSRC Provided by the Ohio Supercomputer Center,” Troy Baer, David Ennis, and Leslie Southern

00–18 “A Fortran Interface to POSIX Treads,” Richard J. Hanson, Clay P. Breshears and Henry A. Gabb

00–17 “Metacomputing: An Evaluation of Emerging Systems,” David Cronk, Graham E. Fagg, Brett D. Ellis and Dorian Arnold

00–16 Comparison of the SWAN and WAM Wave Models for Nearshore Wave Predictions,” Stephen Wornom and David J. S. Welsh

00–15 “Modeling of HPC Platforms and Performance Tuning of DoD Applications,” WenHeng Liu, Neungsoo Park, Santosh Narayanan, Viktor K. Prasanna

00–14 “A Portable Programming Interface for Performance Evaluation on Modern Processors,” S. Browne, J. Dongarra, N. Garner, K. London, and P. Mucci

00–13 “Error and Shape Quality Indicators for Adaptive Refinement and Deforming Finite Elements,” G.F. Carey, J.T. Oden, A.K. Patra, A.I. Pehlivanov, S. Prudhomme, and D. Littlefield

00–12 “Scientific Visualization of Water Quality in the Chesapeake Bay,” Robert Stein, Alan M. Shih, M. Pauline Baker, Carl F. Cerco, and Mark R. Noel

00–11 “Parallel Simulation of Flows in Open Channels at a Super–Critical Condition Using the Finite Element Method,” Shahrouz Aliabadi, Andrew Johnson, Bruce Zellars, Ade Abatan, and Charlie Berger

00–10 “Large–Scale Collective Communication and Load–Balancing on Parallel HPC Systems.” Mark Fahey

00–09 “An Efficient Algorithm for Large–Scale Matrix Transposition,” Jinwoo Suh, Santosh Narayanan, and Viktor K. Prasanna

00–08 “Dual–Level Parallelism Improves Load–Balance in Coastal Ocean Circulation Modeling,” Phu Luong, Clay P. Breshears, and Le N. Ly

00–07 “Execution and Load–Balance Improvements in the CH3D Hydrodynamic Simulation Code,” Phu Luong, Clay P. Breshears, and Henry A. Gabb

00–06 “User’s Guide: Connecting to ERDC MSRC HPC Systems with a Palm Organizer,” Rebecca Fahey and Ron Gunn

00–05 “1999 ERDC PET Training Activities,” Wayne Mastin

00–04 “Implementation of Adaptive Mesh Refinement into an Eulerian Hydrocode,” David Littlefield and J. Tinsley Oden

00–03 “Locating Floating–Point Exceptions on the SGI Origin2000,” Mark R. Fahey

00–02 “MDARUN – A Package of Software for Creating Multidisciplinary Applications with MPI,” Richard Weed

00–01 “Building Multidisciplinary Applications with MPI,” Richard Weed

11. Journal Papers, Presentations, & Reports

CFD – Book

1. *Handbook of Grid Generation*, Thompson, J.F., Soni, B.K., and Weatherill, N.P. (editors), CRC Press, January 1999.

CFD – Journal Publications

1. Soni, B.K. "Grid Generation: Past, Present and Future," *Journal of Applied Numerical Mathematics*, Vol. 32, Issue 4, pp. 261–269, April 2000.
2. Soni, Bharat K., Koomullil, Roy P., Thompson, David S., and Thornburg, Hugh, "Solution Adaptive Grid Strategies Based on Point Redistribution," (to appear) *Journal of Numerical Methods in Engineering.*
3. Koomullil, R.P., and Soni, B.K., "Flow Simulation Using Generalized Static and Dynamic Grids," *AIAA Journal*, Volume 37, Number 12, pp. 1551–1557, December 1999.
4. Li, Zhilin and Soni, B.K. "Fast and Accurate Numerical Approaches for Stefan Problems and Crystal Growth." *The Journal of Numerical Heat Transfer, Part B: Fundamentals* Vol. 35, Issue 4, pp. 461–484, June 1999.

CFD – Proceedings

1. Thompson, D. and Soni, B.K., "Semistructured Grid Generation in Three Dimensions using a Parabolic Marching Scheme," AIAA Paper No. 2000–1004, *AIAA Aerospace Science Meeting*, Reno, Nevada, January 10–14, 2000.
2. Nusca, M.J., Dinavahi, S.P.G., and Soni, B.K., "Grid Adaptive Studies for Reactive Flow Modeling of Gun Propulsion Systems," AIAA Paper No. 99–0970.

CFD – Presentations

1. Thompson, D.S., and Soni, B.K., "Generation of Quad– and Hex–Dominant, Semistructured Meshes using an Advancing Layer Scheme," *8th International Meshing Roundtable,* South Lake Tahoe, CA, October 1999.
2. Soni, B.K., "CFD: State–of–the–Art & State–of–the–Practice," Seminar presented at the Aeronautical Society of India, December 1999.
3. Soni, B.K., "Grid Generation: Mathematics, Numerics and Art," *Conference to honor Dr. S.K. Godunov's 70th Birthday,* Novosibirsk, Russia, August 1999.
4. Soni, B.K., Thornburg, H., Dinavahi, S. "CFD CTA at ARL & ASC MSRC: Training, Technology Transfer and Technology Improvements" *DOD HPC Users Group Meeting,* Monterrey, CA, June 7–11, 1999.
5. Thompson, D.S. and Soni, B.K., "Quad–dominant Semistructured Grid Generation Using a Parabolic Marching Scheme," *4th Mississippi State Conference on Differential Equations and Computational Simulations*, Mississippi State, May 21–22, 1999.
6. Hur, J., Soni, B.K., Koomullil, R.P., and Yang, S., "NURBS in CFD based design optimization," *4th Mississippi State Conference on Differential Equations and Computational Simulations,* Mississippi State, May 21–22, 1999.
7. Koomullil, R.P., and Soni, B.K., "A Generalized Flow Simulation System," *4th Mississippi State Conference on Differential Equations and Computational Simulations,* Mississippi State, May 21–22, 1999.

8. Madhavan, A. and Soni, B.K., “An Adaptive grid system for structured grids with arbitrary topology: Extension of the parallel multiblock adaptive grid system,” *4^{th} Mississippi State Conference on Differential Equations and Computational Simulations*, Mississippi State, May 21–22, 1999.

9. Vu, B. and Soni, B.K., “The use of non–uniform rational B–splines in overset grid generation,” *4^{th} Mississippi State Conference on Differential Equations and Computational Simulations*, Mississippi State, May 21–22, 1999.

CFD – Workshop/Shortcourses

1. Soni, B. K., “Grid Generation Short Course”, Pre–conference course, 8^{th} International Meshing Roundtable Conference, October, 1999.
2. Soni, B. K., “CFD in the HPC environment”, Summer Institute, Clark Atlanta University, June, 1999.
3. Soni, B. K., “CFD Simulation & Applications”, Seminar at Morgan State Uinversity, December, 1999.
4. Soni, B.K., and Bova, S., “CFD – Numerics & Applications”, Summer Institute, Jackson State University, June 1999.

CSM – Journal Publications

1. Carey, G.F. and Ma, M., “Joint Elements, Stress Post–Processing and Superconvergent Extraction with Application to Mohr–Coulomb Failure”, *CNME*, 15, 335–347, 1999.
2. Plaza, A. and Carey, G.F., “Local Refinement of Simplicial Grids Based on the Skeleton, *Applied Numerical Mathematics*, 32, 195–218, 2000.
3. Carey, G.F., Bicken, G., Carey, V., Berger, C., Sanchez, J., “Locally Constrained Projections”, *IJNME*, In Press, January 2000.

CSM – Proceedings

1. Littlefield, D.L., Oden. J.T., Crawford, D., and Hertel, E., “Implementation of Adaptive Mesh Refinement into an Eulerian Hydrocode”, *The 15th U. S. Army Symposium on Solid Mechanics*, Myrtle Beach, SC, April 12 – 16, 1999.
2. Littlefield, D.L., Oden, J.T. and Carey, G.F., “Implementation of Adaptive Mesh Refinement into an Eulerian Hydrocode, *Proceedings of the Department of Defense High Performance Computing Users Group Conference*, Monterey, CA, June 7–11, 1999.
3. Patra, A., Pehlivanov, A.I., Littlefield, D., Carey G.F. and Oden, J.T., “Application of Error Indicatros and Local Adaptive Refinement for Elasto–Plastic Impact Calculation (EPIC), *Proceedings of the Department of Defense High Performance Computing Users Group Conference*, Monterey, CA, June 7–11, 1999.

CSM – Presentations

1. Pehlivanov, A. I. And Carey, G.F., “Hierarchic Data Manipulation and Adaptive Compression Using Octrees”, *Fifth SIAM Conference on Mathematical and Computational Issues in the GeoSciences*, San Antonio, TX, March 22–27, 1999.
2. Littlefield, D.L., Oden, J.T. and Carey, G.F., “Parallel Block Adaptive Mesh Refinement in Eulerian Hydrocodes”, *HPC’99*, San Diego, CA, April 14, 1999.
3. Littlefield, D.L., Oden, J.T., Carey, G.F., Crawford, D., and Hertel, E., “Implementation of Block Adaptive Mesh Refinement into an Eulerian Impact Mechanics Code”, *The 1999 Advanced Simulation Technologies Conference*, San Diego, CA April 11 – 15, 1999. (Abstract only)

4. Littlefield, D.L., Oden, J.T. and Carey, G.F., “Implementation of Adaptive Mesh Refinement into an Eulerian Hydrocode”, *DoD HPC Users Group Meeting*, Monterey, CA, June 7–11, 1999.

5. Patra, A., Pehlivanov, A.I., Littlefield, D.L., Carey, G.F. and Oden, J.T., “Application of Error Indicatros and Local Adaptive Refinement for Elasto–Plastic Impact Calculation (EPIC)”, *DoD HPC Users Group Meeting*, Monterey, CA, June 7–11, 1999.

6. Carey, G.F. and Pehlivanov, A.I., “An Adaptive Octree–Based Scheme for Hierarchic Extraction Compression and Remote Visualization of Data”, *The 5th U.S. National Congress on Computational Mechanics*, Boulder, CO, Aug 4–6, 1999.

7. Littlefield, D.L., and Oden, J.T., “Implementation of Adaptive Mesh Refinement into an Eulerian Impact Mechanics Code”, *The 5th U. S. National Congress on Computational Mechanics*, Boulder, CO, August 4–6, 1999. (abstract only)

8. Carey, G.F. and Walsh, T., “Elements Under Duress”, *Finite Element Circus*, Cornell University, New York, NY, October 1–2, 1999.

9. Carey, G.F. and Walsh, T., “Element quality and experiments with degenerate elements”, *8th Int’l Meshing Roundtable*, Lake Tahoe, NV, October 10–13, 1999.

10. Carey, G.F., “Grid Quality under Adaptive Refinement” in Session Organized by G.F. Carey and D.L. Littlefield on Computational Methods for Transient Problems in Nonlinear Continuum Mechanics, *SES Meeting*, Austin, TX, October 25–27, 1999.

11. Carey, G.F., Pehlivanov, A. and Plaza, A., “Some Aspects of Adaptive Grid Refinement”, *Sixth SIAM Conference on Geometric Design*, Albuquerque, NM, November 2–5, 1999.

12. Carey, G.F., “Multiphysics Modelling in the new Millenium: Problems and Possibilities”, *Workshop on Coupling Multiphysics Problems in Environmental Simulation*, ERDC MSRC, Vicksburg Mississippi by University of Texas EQM personnel and Ohio State CWO personnel, January 12, 2000.

CSM – Workshop/Shortcourses

1. Carey, G.F., “Grid Generation and Adaptive Grids”, Shortcourse, CEWES, Vicksburg, MS, January 13–14, 2000.

2. Oden, J.T., Carey, G.F. and Duarte, A., “ERDC MSRC Seminar Series”, Meshless Methods in Computational Structural Mechanics, Vicksburg, MS, February 14, 2000.

3. PET Report Adaptive Epic. Report in Preparation

4. Littlefield, D.L. and Oden, J. T., “Implementation of Adaptive Mesh Refinement into an Eulerian Hydrocode”, CEWES, Vicksburg, MS, July 1999.

CSM – Reports

1. Patra, A. and Littlefield, D.L., “A report on error indicators for Lagrangian impact mechanics codes”, Institute for Advanced Technology Technical Report No. IAT.R.0185, in publication.

2. Carey, G.F. and Oden, J.T., Report on Organized Specialty Workship on Adaptive Grids, UT Austin, April 1999.

3. Weed, R., “MDARUN– A Package of Software for Creating Multi– disciplinary Applications with MPI,” ERDC MSRC/PET TR/00–02, November 1999.

CWO/EQM – Journal Publications

1. Dawson, C., “Conservative, Shock–Capturing Transport Methods with Nonconservative Velocity Approximations”, to appear in *Computational Geosciences*.

2. Aizinger, V., Dawson, C., Cockburn, B. and Castillo, P., “The Local Discontinuous Galerkin Method for Contaminant Transport”, submitted to *Advances in Water Resources*.

3. Riviere, B., Wheeler, M.F. and Girault, V., "Part I. Improved Energy Estimates for Interior Penalty, Constrained and Discontinuous Galerkin Methods for Elliptic Problems," to appear, *Computational Geosciences.*

4. Ly, L. and Luong, P., "Numerical Multiblock Grids in Coastal Ocean Circulation Modeling," *Journal of Applied Mathematical Modeling*, Volume 23, pp 865–879, 1999.

CWO/EQM – Proceedings

1. Dawson, C., Aizinger, V. and Cockburn, B., "The Local Discontinuous Galerkin Method for Contaminant Transport Problems", to appear, *Proceedings for the First International Symposium on Discontinuous Galerkin Methods*, Brown University, May, 1999.

2. Ly, L., Luong, P., Paduan, J. and Korancin, D., "Response of the Monterey Bay Region to Wind Forcing by an Atmospheric Model," *Proceedings of the American Meteorological Society (AMS) Conference on Coastal Atmospheric and Oceanographic Prediction and Processes*, New Orleans, LA, November 1999.

3. Riviere, B. and Wheeler, M.F., "A Discontinuous Galerkin Method Applied to Nonlinear Parabolic Equations," to appear, *Proceedings of the First International Symposium on Discontinuous Galerkin Methods*, Brown University, May 1999.

4. Riviere, B. and Wheeler, M.F., "Locally Conservative Algorithms for Flow," to appear, *Proceedings of Mathematics of Finite Elements and Applications (MAFELAP)*, Brunel University, June, 1999.

FMS – Book Chapter

1. CRPC Book Chapter, Morgan–Kaufmann 2000 (in progress): *WebHLA based Metacomputing Environment for Forces Modeling and Simulation*

FMS – Proceedings

1. Fox, G.C., Furmanski, W., Krishnamurthy, G., Ozdemir, H.T., Ozdemir, Z., Pulikal, T.A., Rangarajan, K. and Sood, A., "Using WebHLA to Integrate HPC FMS Modules with Web/Commodity based Distributed Object Technologies of CORBA, Java, COM and XML", *Proceedings of the Advanced Simulation Technologies Conference ASTC 99*, San Diego, April 1999.

FMS – Presentations

1. Fox, G.C., Furmanski, W., Krishnamurthy, G., Ozdemir, H., Ozdemir, Z., Pulikal, T.A., Rangarajan, K. and Sood, A., "WebHLA as Integration Platform for FMS and other Metacomputing Application Domains", *Proceedings of the DoD HPC Users Group Meeting*, Monterey, CA, June 8–15, 1999.

C/C – Book Chapters

1. Fox, G.C., "From Computational Science to Internetics. Integration of Science with Computer Science," in a book dedicated to John R. Rice of Purdue University (to be published). http://www.npac.syr.edu/users/gcf/internetics2/

2. Fox, G.C., "Internetics: Technologies, Applications and Academic Fields", in *Feynman and Computation*, edited by A.J.G. Hey, Perseus Books (1999), http://www.npac.syr.edu/users/gcf/internetics/ (no abstract)

3. Fox, G.C., Hurst, K.C., Donnellan, A. and Parker, J., "Introducing a New Paradigm for Computational Earth Science – A Web–Object–Based Approach to Earthquake Simulations", in to appear in a volume of the Geophysical Monograph Series, edited by John Rundle, American Geophysical Union, 2000. http://www.new–npac.org/users/fox/documents/gempapermarch00/

4. Haupt, T., Akarsu, E. and , Fox, G.C., "WebFlow: a Framework for Web Based Metacomputing," in *Lecture Notes in Computer Science Vol. 1593: High Performance Computing and Networking*, edited by P. Sloot, M. Bubak, A. Hoekstra, and B. Hertzberger, Springer (1999).

C/C – Journal Publications

1. Beca, L., Fox, G.C. and Podgorny, M., "Component Architecture for Building Web–based Synchronous Collaboration Systems", *IEEE 8th International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises – WET ICE'99*, IEEE, June 1999, pp. 108–113.

2. Haupt, T., Akarsu, E. and Fox, G.C., "Landscape Management System: A WebFlow Application", *Concurrency–Practice and Experience* (in press).

C/C – Proceedings

1. Akarsu, E., Fox, G.C., Haupt, T., Kalinichenko, A., Kim, K.–S., Sheethaalnath, P. and Youn, C.–H., "Using Gateway System to Provide a Desktop Access to High Performance Computational Resources," in *8th International Symposium on High Performance and Distributed Computing*, IEEE Computer Society (1999).

2. Fox, G.C., "Portals and Frameworks for Web Based Education and Computational Science", in *Proceedings of the Second International Conference on the Practical Applications of Java,* Omer Rana editor. http://www.new–npac.org/users/fox/documents/pajavaapril00/

SPPT – Journal Publications

1. Browne, S., Dongarra, J., Garner, N., Ho, G. and Mucci, P., "A Portable Programming Interface for Performance Evaluation on Modern Processors," *International Journal of High–Performance Computing and Applications,* (to appear).

2. Bova, S.W., Breshears, C.P., Cuicchi, C., Demirbilek, Z. and Gabb, H.A., "Dual–level Parallel Analysis of Harbor Wave Response Using MPI and OpenMP, *International Journal of High Performance Computing Applications*, Volume 14, Number 1, Spring 2000, pp. 49–64.

3. Bova, S.W., Breshears, C.P., Eigenmann, R., Gabb, H.A., Gaertner, G., Kuhn, R., Magro, R., Salvini, R. and Vatsa, V., "Combining Message–passing and Directives in Parallel Applications," *SIAM News*, Volume 32, Number 9, November 1999.

SPPT – Proceedings

1. Bova, S.W., Breshears, C.P., Cuicchi, C., Demirbilek, Z. and Gabb, H.A., "Nesting OpenMP in an MPI Application," *Proceedings of the ICSA 12th International Conference on Parallel and Distributed Computing and Systems*, pp. 566—571, International Society for Computers and their Applications, 1999.

2. Breshears, C.P., Steve W. Bova, Christine Cuicchi, Zeki Demirbilek, Henry A. Gabb, "Using MPI_Connect to Distribute Parallel Applications Across Multiple Platforms," *Proceedings of the International Conference on Parallel and Distributed Processing Techniques And Applications (PDPTA'99)*, Volume I, pp. 383—389, CSREA Press, 1999.

SPPT – Presentations

1. Bova, S.W., Breshears, C.P., Cuicchi, C., Demirbilek, Z., Gabb, H.A., "Using MPI and OpenMP for Dual–level Parallel Execution," *Proceedings of the 1999 DoD HPC Users Group Meeting*, Monterey, CA, June 7—11, 1999.

2. Browne, S., London, K. and Breshears, C.P., "Scalable Performance Analysis Using Dynamic Instrumentation and Virtual Reality Immersion," *1999 DoD HPC Users Group Meeting*, Monterey, CA, June 7—11, 1999.

3. Breshears, C.P., Fahey, M.A. and Gabb, H.A., "Application of Fortran Pthreads to Linear Algebra and Scientific Computing," *41st Cray User Group Conference*, Minneapolis, MN, May 24—28, 1999.

4. Browne, S., Dongarra, J., Garner, N., London, K. and Mucci, P., "A Portable Interface to Hardware Performance Counters on Modern Microprocessors," submitted to the *2000 DoD HPC Users Group Meeting.*

5. Browne, S., Cronk, D., Ellis, B. and Fagg, G., "Metacomputing: An Evaluation of Emerging Systems," submitted to the *2000 DoD HPC Users Group Meeting.*

6. Luong, P., Breshears, C.P. and Gabb, H.A., "Execution and Load–Balance Improvements in the Production Engineering Application CH3D with Dual–Level Parallelism," poster presentation, *Supercomputing99*, Portland, OR, November 13–19, 1999.

USC – Presentations

1. Suh, J. and Prasanna, V.K., "An Efficient Algorithm for Large Scale Matrix Transposition", Submitted to *International Conference on Parallel Processing*, 2000.

2. Park, N., Liu, W., Raghavendra, C. and Prasanna, V.K., "Efficient Matrix Multiplication Using Cache Conscious Data Layouts," *DoD HPC Users Group Meeting*, June 2000.

JSU – Proceedings

1. Jung, G.S., Malluhi, Q.M. and Chawdhury, F., "An Automatically Reconfigurable Distributed Data Storage for High Data Availability", *Proceedings of the International Conference on Parallel and Distributed Computing Systems (PDCS)*, MIT, Cambridge, MA, November 1999.

JSU – Presentations

1. Brown, W.G., Jung, G.S. and Malluhi, Q.M., "Distributed Storage Management for Scalable, High Performance, and Reliable Data Delivery," *DoD Users Group Conference*, Monterey, California, June 1999.

2. Brown, W.G., Malluhi, Q., Mitra, D. and Robinson, M., "Internet–based Synchronous Distance Education: An Experience at Jackson State University", *Future'99*, Jackson, MS, February 1999.

3. Brown, W.G., Jung, G.S. and Malluhi, Q.M., "Java–Based Distributed File Management System Demonstration", *DoD HPC Users Group Conference, Monterey*, California, June 1999.

4. Brown, W.G., Jung, G.S. and Malluhi, Q.M., "JDFMS: A High Performance Storage System", DoD HPCMP Booth, *Supercomputing'99*, Portland, Oregon, November 1999.

CAU – Presentations

1. Parallel Finite Element Computations of Unsteady Free–Surface Flow Problems with Large Deformations. ERDC (Engineering Research and Development Center), Vicksburg, MS, October 5, 1999.

2. Preconditioning Method for Finite Element Computations. Chuo University, Research Institute of Science and Engineering, Tokyo, Japan, December 13, 1999.

3. Parallel Matrix–Free Finite Element Method. Chuo University, Research Institute of Science and Engineering, Tokyo, Japan, December 17, 1999.

4. Scientific Computing for Engineers. Chuo University, Research Institute of Science and Engineering, Tokyo, Japan, December 24, 1999.

5. Parallel Simulation of Free–Surface Flow Problems. Department of Physics, Clark Atlanta University, Atlanta, GA, March 2, 2000.

CAU – Publications

1. S. Aliabadi and S. Shujaee, "Two–Fluid Flow Simulations Using Parallel Finite Element Method", submitted to the *Journal of the Society for Computer Simulation International*.

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
ERC (Mississippi State) – Leadership						
Joe Thompson, PhD	Mississippi State	At University	Distinguished Professor	ERDC MSRC PET Academic Lead	50	21

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
ERC (Mississippi State) – CFD						
David Huddleston, PhD	Mississippi State	At University	Associate Professor	CFD Lead (until May 31, '99)	15	2
Steve Bova, PhD	Mississippi State	On–Site	Research Engineer	CFD On–Site Lead (until July 31, '99)	100	All
Bharat Soni, PhD	Mississippi State	At University	Associate Professor	CFD Lead (from June 1, '99)	20	6
Nathan Prewitt, PhD	Mississippi State	On–Site	Research Engineer	CFD On–Site Lead (from Feb. 1, '00)	100	All

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
TICAM (Texas) & ERC (Mississippi State) – CSM						
J. T. Oden, PhD	Texas	At University	Professor, TICAM DIRECTOR	CSM Lead	10	3
Graham Carey, PhD	Texas	At University	Professor	Co–PI	15	6
David Littlefield, PhD	Texas (Army Inst. for Advanced Tech.)	At University (IAT)	Research Engineer	Research Team Member	50	3
Atanas Pehilvanov, PhD	Texas	At University	Research Engineer	Research Team Member	50	0
Robert McLay, PhD	Texas	At University	Research Engineer	Software Specialist	50	0
Abani Patra, PhD	Buffalo	At University (IAT)	Asst. Professor	Research Engineer	12.5	0
Richard Weed, PhD	Mississippi State	On–Site	Research Engineer	CSM On–Site Lead	100	All

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
Ohio State – CWO						
Keith Bedford, PhD	Ohio State	At University	Professor	CWO Lead	5	5
P. Sadayappan, PhD	Ohio State	At University	Professor	Research Scientist	8	7
Stephen Wornom, PhD	Ohio State	On–Site	Research Scientist	CWO On–Site Lead	100	All
David Welsh, PhD	Ohio State	At University	Sr. Research Associate	Research Engineer	100	7
Rong Wang	Ohio State	At University	Graduate Research Associate	Graduate Research Associate	50	0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
TICAM (Texas) – EQM						
Mary F. Wheeler, PhD	Texas	At University	Professor	EQM Lead	12.5	9
Phu Luong, PhD	Texas	On–Site	Research Associate	EQM On–Site Lead	100	All
Clint Dawson, PhD	Texas	At University	Professor	Co–PI	12.5	7
Victor Parr, PhD	Texas	At University	Consultant	Consultant Programmer	100	8
Jichun Li, PhD	Texas	At University	Research Associate	Development of UTPROJ	75	0
Dharhas Poitina	Texas	At University	Research Assistant	Development of New Solver in CH3D	50	0
Sharon Lozano	Texas	At University	Research Assistant	Taught JSU Summer Course	2	1
Jennifer Proft	Texas	At University	Research Assistant	Taught JSU Summer Course	2	1
Beatrice Riviere	Texas	At University	Research Assistant	Development of Discontinuous Galerkin Methods	37.5	0
Nelson Hallidy	Texas	At University	Staff	Staff Support	29	0
William Wuertz	Texas	At University	Staff	Staff Support	45.8	0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
NPAC (Syracuse) – FMS & C/C						
Leadership					***0.34 (FTE)***	
Geoffrey Fox, PhD	**Syracuse**	**At University**	**Professor**	**FMS & C/C Lead**		**6**
David Bernholdt, PhD	**Syracuse**	**At University**	**Sr. Research Scientist**	**Project Leader**		**2**
Tango Interactive Collaboratory Group					***3.34 (FTE)***	
Marek Podgorny, PhD	**Syracuse**	**At University**	**Sr. Research Scientist**	**Project Leader**		**1**
Roman Markowski, PhD	**Syracuse**	**At University**	**Sr. Research Scientist**	**Research Scientist**		**0**
Greg Lewandowski	**Syracuse**	**At University**	**Research Scientist**	**Research Scientist**		**0**
Tom Major	**Syracuse**	**At University**	**Research Scientist**	**Research Scientist**		**0**
Konrad Olsweski	**Syracuse**	**At University**	**Research Scientist**	**Research Scientist**		**0**
Pawel Roman	**Syracuse**	**At University**	**Research Scientist**	**Research Scientist**		**0**

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
NPAC (Syracuse) – FMS & C/C						
Tom Stachowiak	Syracuse	At University	Research Scientist	Research Scientist		0
Remek Trzaska	Syracuse	At University	Research Scientist	Research Scientist		0
Bart Winnowicz	Syracuse	At University	Research Scientist	Research Scientist		0
Luke Beca	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Bokyun Na	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Interactive Web Technologies Group					*1.44 (FTE)*	
Wojtek Furmanksi, Ph.D	Syracuse	At University	Sr. Research Scientist	Project Leader		1
Tom Haupt, Ph.D	Syracuse	At University	Sr. Research Scientist	Project Leader		2

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
NPAC (Syracuse) – FMS & C/C						
Erol Akarsu	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Hasan Ozdemir	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Zeynep Ozdemir	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Tom Pulikal	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Hojung Lim	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Krishnan Rangarajan	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Anusha Shankar	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Anand Rau	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Mohan Naidu	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Narmada Rustumsingh	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
NPAC (Syracuse) – FMS & C/C						
Alexy Kalinichenko	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Kan–Seok Kim	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Praveen Sheethaalnath	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Choo–Han Youn	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Computational Science Education Group					*1.07 (FTE)*	
Nancy McCracken, Ph.D	Syracuse	At University	Sr. Research Scientist	Project Leader		0
Ozgur Balsoy	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Saleh Elmohamed	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Meyrem Ispirli	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
NPAC (Syracuse) – FMS & C/C						
Mehmet Sen	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Shrideep Pallickara	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Quiang Zheng	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Dongmin Kim	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Norka Lucena	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
Jianxiang Jim	Syracuse	At University	Graduate Research Assistant	Graduate Research Assistant		0
DATABASE Applications Group					0.08 (FTE)	
Yuping Zhu	Syracuse	At University	Research Scientist	Research Scientist		0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
CRPC (Rice, Tennessee) – SPP Tools						
Ken Kennedy, Ph.D	Rice	At University	Director	Project Director	1	0
Richard Hanson, Ph.D	Rice	At University	Research Scientist	SPP Tools Lead	68	6
Clay Breshears, Ph.D	Rice	On–Site	Research Scientist	SPPT On–Site Lead	100	All
John Mellor–Crummey, Ph.D	Rice	At University	Research Scientist	Research Scientist	8	0
John Bachir	Rice	At University	Technical Student	Technical Support	8	0
Danny Powell	Rice	At University	Contract Administration	Graduate Research Assistant	7	2
Rana Darmara	Rice	At University	Graduate Research Assistant	Graduate Research Assistant	3	0
Kathryn O’Brien	Rice	At University	Administrative Assistant	Secretarial/Clerical	14	0
Corina Cardenas	Rice	At University	Secretary	Secretarial/Clerical	3	0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
CRPC (Rice, Tennessee) – SPP Tools						
Shirley Browne, PhD	Tennessee	At University	Associate Director	PI/PAPI FE Technical Manager	15	0
Susan Blackford	Tennessee	At University	Research Associate	Consultant on Math Libraries	5	0
David Cronk, PhD	Tennessee	At University	Post–Doctoral Research Associate	Research/Technical Work on Metacomputing FE	32	0
Victor Eijkhout, PhD	Tennessee	At University	Research Associate	Consultant on Math Libraries	7.5	0
Graham Fagg, PhD	Tennessee	At University	Research Assistant Professor	PI/MPI–Connect Metacomputing FEs	40	2
George Ho	Tennessee	At University	Research Consultant	Technical Work PAPI FE	5	0
Tracey Lee	Tennessee	At University	Sr. Budget Assistant	Administrative Support	12	0
Kevin London	Tennessee	At University	Research Associate	Technical Work MPI–Connect FE	30	0
Phil Mucci	Tennessee	At University	Research Consultant	Lead/PAPI FE	20	0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
CRPC (Rice, Tennessee) – SPP Tools						
Scott Wells	Tennessee	At University	Program Director	Business Manager	18	0
NCSA (Illinois) – SV						
Polly Baker, PhD	Illinois	At University	Associate Director	SV Lead	20	5
Alan Shih, PhD	Illinois	At University	Research Scientist	Research Scientist	15	2
Jackson State University						
Willie G. Brown, PhD	Jackson State	At University	Assistant Vice President	JSU Lead	10	10
Jeton McClinton	Jackson State	At University	Administrative Assistant	Administrative/ Clerical	25	2
Brenda Rascoe	Jackson State	At University	Administrative Assistant	Administrative/ Clerical	50	0
Michael Robinson	Jackson State	At University	Network Training Specialist	Distance Education Technical Lead	33	0

Table 1
Technical Support Team Personnel

Team Member	Affiliation	Location	Title	Role	% Time	Days On–Site
Jackson State University						
Timothy Ward	Jackson State	At University	Network Training Specialist	Distance Education Technical Lead	50	0
Mildred (Milti) Leonard	Jackson State	At University	Scientific Visualization Specialist	Scientific Visualization Support	33	10
Edgar Powell	Jackson State	At University	Scientific Visualization Specialist	Scientific Visualization Support	50 (thru Sept)	10
Chuck Patrick	Jackson State	At University	Scientific Visualization Specialist	Scientific Visualization Support	50 (from Sept)	10

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
ERC (Mississippi State) – Leadership				
ERDC MSRC	Mississippi State	Thompson	21	Leadership
HPCMO	Mississippi State	Thompson	2	Leadership
Monterey, CA	Mississippi State	Thompson	5	DoD HPC Users Group Meeting
Portland, OR	Mississippi State	Thompson	6	Supercomputing ’99

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
ERC (Mississippi State) – CFD				
ERDC MSRC	Mississippi State	Soni	5	Semi–annual and annual ERDC MSRC PET review CFD on–site lead interview Visit with users and PET team
Jackson State	Mississippi State	Soni	1	Summer Institute
Clark Atlanta	Mississippi State	Soni	2	Summer Institute
Morgan State	Mississippi State	Soni	2	Seminar
Redstone Arsonal	Mississippi State	Soni	2	Outreach
AEDC	Mississippi State	Soni	2	Outreach
Monterey, CA	Mississippi State	Soni	4	DoD HPC User’s Group meeting
Jackson State	Mississippi State	Bova	1	Summer Institute
Monterey, CA	Mississippi State	Bova	4	DoD HPC User’s Group meeting

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
TICAM (Texas) & ERC (Mississippi State) – CSM				
ERDC MSRC	Texas	Oden, Carey, Littlefield, Duarte	1	Present progress to Structures lab members & discuss needs, planning. Give mini–seminar on Meshless methods & data structures at ERDC MSRC.
Sandia	Texas	Littlefield	1	Collaboration with SNLA Application analysts on CTH
Sandia	Texas	Carey, McLay, Pehlivanov & Students	2	Collaboration on unstructured grids & software
Texas	Buffalo	Patra	1 Month	Work with Texas associates on indicator & element quality modules
Texas	Buffalo	Patra	2 Weeks	Follow–up studies on indicator & report preparation
ERDC MSRC	Texas	Carey	3	Shortcourse on Unstructured & Adaptive Grids
ERDC MSRC	Texas	Oden, Carey, Littlefield	3	ERDC MSRC PET Annual Review

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
Ohio State – CWO				
NAVO MSRC	Ohio State	Bedford, Sadayappan Wornom, Welsh	3	Discussed past/future PET CWO research & NAVOCEANO with CWO Lead; seminar on PET CWO research
ERDC MSRC	Ohio State	Sadayappan, Welsh	2, 3	Taught CWO training course
Monterey, CA	Ohio State	Sadayappan, Wornom Welsh	2, 7, 5	DoD HPC Users Group Meeting; seminar at NRL–Monterey
Jackson State	Ohio State	Sadayappan, Wornom Welsh	2	JSU Summer Institute
ERDC MSRC	Ohio State	Bedford, Sadayappan Welsh	2	Planning meeting concerning CHL wave modeling program; seminar on PET CWO
Ohio State	Ohio State	Wornom	1	ERDC MSRC PET Annual Review preparation
New Orleans, LA	Ohio State	Welsh	3	American Meterological Society’s Third Conference; presentation
ERDC MSRC	Ohio State	Sadayappan, Welsh	2	PET CWO/EQM training workshop; presentations
Boulder, CO	Ohio State	Wornom, Welsh	5	Attended training course

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
		Ohio State – CWO		
Ohio State	**Ohio State**	**Wornom**	**1**	**ERDC MSRC PET Annual Review preparation**
ERDC MSRC	**Ohio State**	**Bedford, Sadayappan**	**2**	**ERDC MSRC PET Annual Review**

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
		TICAM (Texas) – EQM		
Texas NAVO MSRC	Texas	Luong	4	Attend meeting/conference
Texas	Texas	Luong	8	Perform research activities
Monterey, CA	Texas	Luong, Dawson	5, 2	DoD HPC Users Group Meeting
Jackson State	Texas	Cutchin, Dawson, Lozano, Proft, Wheeler	2	Conduct lecture/teach course, attend meeting/conference
Texas	Texas	Luong	7	Perform research activities
ERDC MSRC	Texas	Wheeler	1	Attend meeting/conference
ERDC MSRC	Texas	Wheeler, Dawson	3	Conduct lecture/teach course
Texas	Texas	Luong	4	Attend meeting/conference
Portland, OR	Texas	Luong	5	Attend Supercomputing ’99
Texas	Texas	Luong	6	Perform research activities

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
TICAM (Texas) – EQM				
ERDC MSRC	Texas	Dawson	2	Conduct lecture/teach course
NAVO MSRC	Texas	Luong, Wheeler	1	Visit NAVO MSRC
NPAC (Syracuse) – FMS & C/C				
ERDC MSRC	Syracuse	Bernholdt, Fox	2	ERDC MSRC PET Annual Review
Portland, OR	Syracuse	Fox	7	Presentations & Discussions of ERDC–Supported work, SC ’99
ERDC MSRC	Syracuse	Fox	2	Distance Training Workshop
ERDC MSRC	Syracuse	Fox	2	ERDC MSRC PET Mid–Year Review
Jackson State	Syracuse	McCracken, Podgorny	2	Distance Education Workshop
ERDC MSRC	Syracuse	Haupt	2	Land Management System Workshop
ERDC MSRC	Syracuse	Furmanski, Pulikal	1	Discussions & Software Installation
Jackson State	Syracuse	Furmanski, Pulikal	1	Summer Institute Presentation
Jackson State	Syracuse	Fox, McCracken	1	Summer Institute Presentation

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
NPAC (Syracuse) – FMS & C/C				
Monterey, CA	Syracuse	Bernholdt, Fox Furmanski, Haupt, McCracken, Podgorny	4	Tutorials, Presentations, Discussions at DoD HPC Users Group Meeting
ERDC MSRC	Syracuse	Podgorny	1	Meeting with User Interested in Collaboration Tools
SPAWAR	Syracuse	Furmanksi	2	CHSSI FMS–4 Beta Test
Metron	Syracuse	Furmanksi	2	CHSSI FMS–3 Beta Test
SCS Conference on Advanced Simulation Technologies	Syracuse	Furmanski	5	Present ERDC MSRC–support work & Chair Session
CRPC (Rice, Tennessee) – SPPT				
Monterey, CA	Tennessee	Mucci	3	Organized & lead DoD Programming Tools BOF & Presented Paper on PAPI at DoD HPC Users Group Meeting
ERDC MSRC	Tennessee	Fagg	2	ERDC MSRC PET Annual Review
Yorktown Heights, NY	Tennessee	Mucci	6	Collaborate with IBM Research on IBM Power implementation of PAPI

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
CRPC (Rice, Tennessee) – SPP Tools				
Yorktown Heights, NY	Tennessee	Mucci	2	Collaborate with IBM Research on IBM Power implementation of PAPI
Chicago, IL	Tennessee	Fagg	4	Attend Grid Forum meeting in support of Metacomputing Evaluation Project
Portland, OR	Tennessee	Fagg	9	Attend Supercomputing ’99
San Antonio, TX	Rice	Hanson	3	SIAM Conference on Parallel Computing
West Lafayette, IN	Rice	Hanson	2	IFIP Symposium at Purdue
Monterey, CA	Rice	Hanson	5	DoD HPC Users Group Meeting
Jackson State	Rice	Hanson	1	Tutorial/Summer Institute
Portland, OR	Rice	Hanson	5	Attend Supercomputing ’99
Jackson State	Rice	Hanson	1	Tutorial/Visualization Conference
ERDC MSRC	Rice	Hanson	3	ERDC MSRC PET Annual Review
Rice	Rice	Breshears	5	Pthreads Tutorial
Boulder, CO	Rice	Breshears	3	Ptools Consortium
Rice	Rice	Breshears	2	ERDC MSRC CWO Tutorial

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
CRPC (Rice, Tennessee) – SPPT				
ASC MSRC	Rice	Breshears	4	IBM SP Power 3 Tutorial
Minneapolis, MN	Rice	Breshears	5	Presentation/Cray Users Group
Monterey, CA	Rice	Breshears	5	DoD HPC Users Group Meeting
Las Vegas, NV	Rice	Breshears	5	Presentation/Parallel Programming Conference
Tennessee	Rice	Breshears	5	UTK/PET Review
Mississippi State	Rice	Breshears	2	MSU/ERC Users Group
Rice	Rice	Breshears	2	Pthreads Project Review
Portland, OR	Rice	Breshears	5	Attend Supercomputing ’99/Tutorial
NAVO MSRC	Rice	Breshears	1	NAVO Review/POM Code
NCSA (Illinois) – SV				
ERDC MSRC	Illinois	Baker	3	ERDC MSRC PET Annual Review
Jackson State	Illinois	Shih	2	Visualization Training
ERDC MSRC	Illinois	Folk, Jones, Cheng	2	HDF Training
ERDC MSRC	Illinois	Folk, Jones, Cheng	3	HDF Training

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
NCSA (Illinois) – SV				
ERDC MSRC	Illinois	Baker	2	Technology Transfer
ERDC MSRC	Illinois	Shih	2	Technology Transfer
Los Angeles, CA	Illinois	Baker	6	Graphics Conference
Portland, OR	Illinois	Baker	6	Attend Supercomputing ’99
Monterey, CA	Illinois	Baker	6	DoD HPC Users Group Meeting
Jackson State University				
ERDC MSRC	Jackson State	Leonard	1	Scientific Visualization Seminar
Bethesda, MD	Jackson State	Robinson	4	Annual Webmasters Workshop
Bowling Green, KY	Jackson State	Robinson	1	Distance Learning/Tango Seminar
Monterey, CA	Jackson State	Brown	5	DoD HPC Users Group Meeting
ERDC MSRC	Jackson State	Brown	2	ERDC MSRC PET Annual Review
ERDC MSRC	Jackson State	Brown	1	Scientific Visualization Consultation
ERDC MSRC	Jackson State	Wicks	1	Scientific Visualization Consultation
ERDC MSRC	Jackson State	Patrick	1	Scientific Visualization Consultation
Alcorn State	Jackson State	Robinson	1	Web–Based Education Consultation

Table 2
Team Travel

Destination	Institution	PET Personnel	Duration Days	Purpose
Jackson State University				
Alcorn State	Jackson State	Ward	1	Web–Based Education Consultation
San Francisco, CA	Jackson State	Patrick	5	Vis’99 Conference
ERDC MSRC	Jackson State	Patrick	1	Scientific Visualization Consultation
ERDC MSRC	Jackson State	Wicks	2	Ensight Workshop
ERDC MSRC	Jackson State	Patrick	2	Ensight Workshop
Portland, OR	Jackson State	Patrick	4	Supercomputing ’99
ERDC MSRC	Jackson State	Wicks	4	Advance Visual Systems Training
ERDC MSRC	Jackson State	Patrick	4	Advance Visual Systems Training
ERDC MSRC	Jackson State	Brown	2	ERDC MSRC PET Annual Review
ERDC MSRC	Jackson State	Patrick	2	ERDC MSRC PET Annual Review
Robinsonville, MS	Jackson State	Rascoe	2	Creating Futures Through Technology Conference

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CFD					
Jay Boris	NRL	CFD	Soni	Visit	CFD PET Program and CHSSI Software Discussion
Ravi Ramamanti	NRL	CFD	Soni	Visit	Outreach
Robert Meakin	NASA Ames	CFD	Soni, Bova	Telephone/ E–mail	Outreach
Jerry Mettey	AEDC	CFD	Soni	Telephone/ E–mail	Outreach
Clark Mikkelsan	Redstone Arsenal	CFD	Soni	Visit	Outreach, Tech Transfer
Kevin Kennedy	Redstone Arsenal	CFD	Soni	Visit	Outreach, Tech Trasnfer
Dr. Tai	David Taylor	CFD	Soni	E–mail	Outreach
Bob Bernard	ERDC	CFD	Soni, Bova	Visit	Outreach
Billy Johnson	ERDC	CFD	Soni, Bova	Visit	Outreach

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CSM					
Raju Namburu	ERDC/ARL	CSM	Carey/Oden/Littlefield	Phone, Email Visits	CSM workshop; CTH application; UT Adaptive Workshop; Adaptive CTH
Stephen Akers	ERDC	CSM/EQM	Weed	Phone, Email Visits	Coordination – EPIC parallel code development & parallel programming workshop. Briefing on PET focused effort activites
Robert Styrk	Alliant System (ERDC SL contractor)	CSM	Weed	Email	Consultation/advice regarding EPIC parallel code development
Robert Britt	SAIC (ERDC SL contractor)	CSM	Weed	Phone, Email Visits	Support for implementation of SAGE code on ERDC MSRC systems
Kent Kimsey Dan Scheffler David Kleponis	ARL	CSM	Littlefield	Phone, Visits	Application Discussions

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
Brenda Martin	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Workshop	Training
Lihwa Lin	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Workshop	Training
Rao Vermulakouda	ERDC CHL	CWO/EQM	Sadayappan, Welsh Wornom	Workshop	Training
Barbara Tracy	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Workshop	Training
Ed Thompson	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Workshop	Training
Alex Carillo	ERDC CHL	SPPT	Sadayappan, Welsh Wornom	Workshop	Training
Rao Vermulakouda	ERDC CHL	CWO/EQM	Sadayappan, Welsh	Workshop	Training
Larry Hsu	NRL/SSC	CWO	Sadayappan, Welsh	Workshop	Training

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
Matt Bettencourt	SSC CHL	CWO	Sadayappan, Welsh	Workshop	Training
Mark Dortch	ERDC EL	EQM	Sadayappan, Welsh	Workshop	Training
Ronald Heath	ERDC CHL	CWO	Sadayappan, Welsh	Workshop	Training
Peter Orlin	NAVOCEANO	CWO	Sadayappan, Welsh	Workshop	Training
Michael Brooking	NAVOCEANO	CWO	Sadayappan, Welsh	Workshop	Training
Bernard Hsieh	ERDC R&DC	CWO	Sadayappan, Welsh	Workshop	Training
Christine Cuicchi	ERDC ITL	SPPT	Sadayappan, Welsh	Workshop	Training
Robert Bernard	ERDC CHL	CWO	Sadayappan, Welsh	Workshop	Training

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
Peter Gruzinskab	NAVOCEANO	CWO	Sadayappan, Welsh	Workshop	Training
Andy Hggs	NAVOCEANO	CWO	Sadayappan, Welsh	Workshop	Training
Bob Jensen	ERDC CHL	CWO	Sadayappan, Welsh	Workshop	Training
Stacy Howington	ERDC CHL	CWO	Sadayappan, Welsh	Workshop	Training
Jackie Hallberg	ERDC CHL	CWO	Sadayappan, Welsh	Workshop	Training
Fred Tracy	ERDC ITL	EQM	Sadayappan, Welsh	Workshop	Training
George Heburn	CNMOC SSC	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Michael Carron	NAVOCEANO	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Larry Hsu	NRL SSC	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
Matt Bettencourt	SSC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Timothy Keen	NRL SSC	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Carl Szczechowski	NAVOCEANO	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Robert Willems	SSC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Igor Shulman	SSC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Alan Wallcraft	NRL SSC	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Seminar/Discussions on PET CWO efforts
Don Resio	ERDC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Presentation/Discussions of future PET CWO efforts
Jane McKee Smith	ERDC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Presentation/Discussions of future PET CWO efforts
Lori Hadley	ERDC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Presentation/Discussions of future PET CWO efforts

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
Bob Jensen	ERDC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Presentation/Discussions of future PET CWO efforts
Zeki Demirbilek	ERDC CHL	CWO	Bedford, Sadayappan Welsh, Wornom	Visit	Presentation/Discussions of future PET CWO efforts
Don Resio	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Visit	Discussed future PET CWO efforts
Jane McKee Smith	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Visit	Discussed future PET CWO efforts
Bob Jensen	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Visit	Discussed future PET CWO efforts
Zeki Demirbilek	ERDC CHL	CWO	Sadayappan, Welsh Wornom	Visit	Discussed future PET CWO efforts
Rao Vermulakouda	ERDC CHL	CWO/EQM	Welsh	Phone	Discussed data availability for WAM/CH3D–SED deployment in San Diego Bay
Rao Vermulakouda	ERDC CHL	CWO/EQM	Welsh	Visit	Supplied data for WAM/CH3D–SED deployment in San Diego Bay
Jeff Holland	ERDC CHL	EQM	Welsh	Email	Planned meeting on CH3D–SED parallelization

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
			CWO		
Jeff Holland	ERDC CHL	EQM	Sadayappan, Welsh Wornom	Visit	Discussed PET efforts to parallelize CH3D–SED
Rao Vermulakouda	ERDC CHL	CWO/EQM	Sadayappan, Welsh Wornom	Visit	Discussed PET efforts to parallelize CH3D–SED
Rao Vermulakouda	ERDC CHL	CWO	Welsh	Email	Discussions concerning CH3D–SED parallelization
Zeki Demirbilek	ERDC CHL	CWO	Welsh	Phone	Discussion of PET efforts on Boussinesq model
Don Resio	ERDC CHL	CWO	Welsh	Email	Collaboration on PET Focused Effort proposals
Jane McKee Smith	ERDC CHL	CWO	Welsh	Email	Collaboration on PET Focused Effort proposals
Bob Jensen	ERDC CHL	CWO	Welsh	Email	Collaboration on PET Focused Effort proposals
Zeki Demirbilek	ERDC CHL	CWO	Welsh	Email	Collaboration on PET Focused Effort proposals
Don Resio	ERDC CHL	CWO	Welsh	Meeting	Discussion of future PET Focused Effort proposals

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
Don Resio	ERDC CHL	CWO	Welsh	Phone	Planning of ERDC CHL wave modeling group meeting
Lori Hadley	ERDC CHL	CWO	Welsh	Email	Planning of ERDC CHL wave modeling group meeting
Don Resio	ERDC CHL	CWO	Welsh	Email	Planned meeting to discuss PET Focused Effort proposals
Joe Gailani	ERDC CHL	CWO	Welsh	Phone	Collaboration on PET Focused Effort proposals
Michael Brooking	NAVOCEANO	CWO	Welsh	Email	Set–up access for OSU to Adruatuc Sea data for CH3D–SED
Peter Orlin	NAVOCEANO	CWO	Welsh	Email	Discussed capabilities of WCBL model
Peter Orlin	NAVOCEANO	CWO	Welsh	Email	Discussion of PET Focused Effort proposals
Ann Sherlock	ERDC CHL	CWO	Welsh	Email	Sherlock supplied OSU with F90 version of STWAVE
Michael Carron	NAVOCEANO	CWO	Welsh	Email	Welsh supplied pre–print report on PET CWO efforts for NAVOCEANO/NRL–SSC scientists

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
George Heburn	CNMOC/SSC	CWO	Wornom, Welsh Bedford	Email	Planned visit to Stennis Space Center
Larry Hsu	NRL/SSC	CWO	Bedford, Sadayappan Welsh, Wornom	Email	Discussion of PET CWO efforts
Jeff Holland	ERDC CHL	EQM	Welsh	Email	Discussed release of WAM/CH3D–SED/WCBL to DoD users
Billy Johnson	ERDC CHL	CWO	Welsh	Email	Discussed release of WAM/CH3D–SED/WCBL to DoD users
Bob Jensen	ERDC CHL	CWO	Welsh	Email	Discussed release of WAM/CH3D–SED/WCBL to DoD users
Jeff Holland	ERDC CHL	EQM	Welsh	Email	Distribution of PET pre–print reports
Bob Jensen	ERDC CHL	CWO	Welsh	Email	Distribution of PET pre–print reports
Jane McKee Smith	ERDC CHL	CWO	Welsh	Email	Smith supplied OSU with STWAVE report
Alan Wallcraft	NRL/SSC	CWO	Wornom	Email	Discussed how PET efforts could aid Wallcraft’s work

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
CWO					
Bob Jensen	ERDC CHL	CWO	Wornom	Email	Collaboration on WAM/SWAN comparison research
Lori Hadley	ERDC CHL	CWO	Wornom	Phone	Deployment of SWAN

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
			EQM		
Jeff Holland	ERDC	EQM	Wheeler, Dawson, Luong	Visit	Discussed projection code & status of project
Charlie Berger	ERDC	EQM	Wheeler, Dawson, Luong	Visit	Discussed projection code & status of project
Charlie Berger	ERDC	EQM	Dawson, Wheeler	Email	Discussed discontinuous Galerkin method & possible incorporation into ADH
Fred Tracy	ERDC	EQM	Wheeler, Dawson, Luong	Visit	Discussed projection code & status of project
Rao Vermulakouda	ERDC	EQM	Wheeler, Dawson, Luong	Visit	Discussed projection code & status of project
Stacy Howington	ERDC	EQM	Wheeler, Dawson, Luong	Visit	Discussed projection code & status of project
Robert Bernard	ERDC	EQM	Wheeler, Dawson, Luong	Visit	Discussed projection code & status of project
Carl Cerco	ERDC	EQM	Dawson	Phone	Discussed projection code & connection with CE–QUAL–ICM

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
EQM					
Barry Bunch	ERDC	EQM	Dawson	Email	Obtain data set for CH3D–Z
Charlie Berger	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Gary Brown	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Stacy Howington	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Jackie Hallberg	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
John Peters	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Fred Tracy	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Jane Smith	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Rao Vermulakouda	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Mark Dortch	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Ron Heath	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Bernard Hsieh	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Christine Cucchi	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Barry Bunch	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Carl Cerco	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Robert Bernard	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Robert Jensen	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Billy Johnson	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support
Tom McGehee	ERDC	EQM	Luong	Phone, Email	Workshop & EQM support

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
EQM					
Peter Orlin	NAVO	EQM	Dawson	Email	Obtain data set for CH3D–Z
Larry Hsu	NAVO	CWO	Luong	Email	Workshop & CWO support
Matt Bettencourt	NAVO	CWO	Luong	Email	Workshop & CWO support
Michael Brooking	NAVO	CWO	Luong	Email	Workshop & CWO support
Pete Gruzinskas	NAVO	CWO	Luong	Email	Workshop & CWO support
Andy Haas	NAVO	CWO	Luong	Email	Workshop & CWO support
Martin Guillot	NAVO	CWO	Luong	Email	Workshop & CWO support
Alice Gilliland	EPA	EQM	Luong	Email	Workshop
Joan Novak	EPA	EQM	Luong	Email	Workshop
Le Ly	NAVO	CWO	Luong	Phone, Email	Workshop & CWO support
Jeffrey Holland	ERDC	EQM	Parr	Visit	Discuss requirements for UTPROJ & CH3D–Z
Gary Brown	ERDC	EQM	Parr	Phone, Email Visit	Obtain data sets for UTPROJ & discuss requirements of UTPROJ, demo prototype
Charlie Berger	ERDC	EQM	Parr	Phone, Email Visit	Obtain data sets for UTPROJ & discuss requirements of UTPROJ, demo prototype

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
EQM					
Carl Cerco	ERDC	EQM	Parr	Phone, Visit	Discussed code require–ments of UTPROJ & future enhancements to CE–QUAL–ICM
Barry Bunch	ERDC	EQM	Parr	Phone	Obtain data set for CH3D–Z discuss code requirements of UTPROJ & future ehancements to CE–QUAL–ICM
Mark Noel	ERDC	EQM	Parr	Phone, Email Visit	Ongoing support of CE–QUAL–ICM
Terry Gerald	ERDC	EQM	Parr	Phone, Email Visit	Ongoing support of CE–QUAL–ICM/TOXI
Rao Vermulakouda	ERDC	EQM	Parr	Email, Visit	Discussed enhancements to CE–QUAL–ICM, ADCIRC, UTPROJ

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
EQM					
George Hebrun	NAVO	CWO	Luong	Visit	Discussed upcoming seminar at NAVO PET
Peter Gruzinskas	NAVO	CWO	Luong	Visit	Discussed upcoming seminar at NAVO PET
Donald Durham (CNMOC TD)	NAVO	CWO	Wheeler, Luong	Visit	Discussed issues supporting EQM users at NAVO MSRC
James Rigney John Blaha	NAVO	EQM CWO	Wheeler, Luong	Visit	Discussed UT Austin EQM team support to the NGLI (Northern Gulf of Mexico Littoral Initiative) project
Steve Adamec NAVO MSRC Director	NAVO	EQM CWO	Wheeler, Luong	Visit	Discussed UT Austin EQM team support to the NGLI (Northern Gulf of Mexico Littoral Initiative) project & EQM at NAVO MSRC

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
FMS					
Steve Bishop	Ft. Belvoir	FMS	Furmanski	Phone, Email Visit	Joint work on parallel CMS, general strategy
Pamela Jacobs	Ft. Belvoir	FMS	Furmanski	Phone, Email Visit	Joint work on parallel CMS
Keith Snively	Ft. Belvoir	FMS	Furmanski	Phone, Email Visit	Joint work on parallel CMS, technical consulting
Bill Smith	NRL	FMS	Furmanski	Phone, Email Visit	Planning PET support for Web–based SPEEDES
Henry Ng	NRL	FMS	Furmanski	Phone, Email Visit	Planning PET support for Tempo/Thema training
Jeff Wallace	SPAWAR	FMS	Furmanski	Phone, Email Visit	Participate in FMS–5 on HPC RTI
Bob Wasilausky	SPAWAR	FMS	Furmanski	Phone, Email Visit	PET support for FMS CHSSI projects
Jeff Steinman	Metron	FMS	Furmanski	Phone, Email Visit	Planning PET support for SPEEDES training

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
FMS					
Jim Brutacao	Metron	FMS	Furmanski	Phone, Email Visit	Planning PET support for SPEEDES training
Larry Peterson	SPAWAR	FMS	Furmanski	Phone, Email Visit	Joint work on Intelligent Agents
Mark Roberts	COLSA	FMS	Furmanski	Phone, Email Visit	Planning PET support for e–ModSAF training
C/C					
K. Krell	ERDC	EQM	Haupt	Email	Provided source codes & instructions on WebFlow
J. Holland	ERDC	EQM	Haupt	Email	Planning LMS workshop
J. Holland M. Krell	ERDC	EQM	Haupt	Visit	Discussed & planned new phase of LMS project
J. Holland M. Krell	ERDC	EQM	Haupt	Email	Comments on meeting summary

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
			FMS & C/C		
J. Holland K. Krell	ERDC	EQM	Haupt	Email	Syracuse milestones; questions & concerns
J. Holland	ERDC	EQM	Haupt	Email	Discussed possibility of near–term ARAMS demo
J. Holland	ERDC	EQM	Haupt	Visit	Announced port of LSM to latest COBRA–based verson of WebFlow
J. Holland	ERDC	EQM	Haupt	Email	Discussed personnel change
J. Holland	ERDC	EQM	Haupt	Phone	Discussed personnel change
J. Holland W. Ingram	ERDC	EQM	Haupt	Visit	WebFlow tutorial; installed latest CORBA–based WebFlow; planning for project
J. Holland W. Ingram	ERDC	EQM	Haupt	Email	Follow–up to meeting; more detailed plans & division labor
J. Holland	ERDC	EQM	Haupt	Email	Comments & refinement of plans above

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
FMS & C/C					
J. Holland	ERDC	EQM	Haupt	Email	Announced availability of “interceptor” to link legacy codes & WebFlow middleware
J. Holland	ERDC	EQM	Haupt	Email	Progress check
J. Holland	ERDC	EQM	Haupt	Phone	Progress check
W. Ingram	ERDC	EQM	Haupt	Email	Progress check
SPP Tools					
R. Maier	AHPCRC	EQM	Fagg	Phone	Discussed future use of MPI–2 parallel I/O in Contaminant Dispersion challenge code
A. Sherlock	ERDC	CWO	Breshears, Hanson	Visit	Improve performance of STWAVE code

Table 3
ERDC MSRC User Contacts

CEWES User	User Site	CTA	ERDC PET Team Member	Mode of Contact	Purpose/Result
SV					
Carl Cerco	ERDC	EQM	Baker, Shih	Phone, Email Visit	Tool development & transfer
Carl Cerco	ERDC	EQM	Shih	Visit, Email	Visualization production
Mark Noel	ERDC	EQM	Shih	Phone, Email	Tool development/transfer & training
Ron Heath	ERDC	EQM	Folk	Phone, Email	Data management

Table 4
Tools Implemented

Tool	Status	Purpose	Users	Providing Institution	Impact
CWO					
WCBL	Code written & deployed; testing is ongoing	Combines wave–current marine bottom boundary layer model can be used to couple wave, circulation & sediment transport	J. Gailani, B. Jensen, B. Johnson, J. Holland	Ohio State	Used to couple the CH3D–SED circulation/ sediment model & the WAM wave model. Will be used to provide numerical modeling for a dredged material disposal experiment.
EQM					
KeLP	Targeted for work	Provide MPI for quick development	EQM personnel	Texas/NPACI	Used to develop parallel version of UTPROJ
FMS					
WebHLA	Work in progress	Simulation, integration, & interoperability	Ft. Belvoir, SPAWAR TECOM	Syracuse	HLA, Web & commodity technology integration

Table 4
Tools Implemented

Tool	Status	Purpose	Users	Providing Institution	Impact
SPPT					
TotalView	Purchased & Installed	To provide a robust, easy–to–use tool for debugging parallel codes	Computational Migration Group & other users that CMG supports Developers of MPI & shared memory parallel programs	Etnus (vendor) Tennessee	Understanding the execution of parallel codes in order to find & fix elusive bugs Enabled CMG to more effectively support users in their debugging tasks
UTK has worked with ERDC MSRC systems staff to get TotalView properly installed & integrated with the queing system. UTK has provided site–specific usage information, training, & a web–based tutorial for TotalView. UTK served as a beta–tested for new releases of TotalView, tested the ERDC MSRC installations, & reported bugs to the TotalView developer.					
Vampir	Purchased & Installed	Provide an effective tool for analyzing & tuning communication performance of MPI parallel codes	EQM CTA	Pallas (vendor) Tennessee	Enabled ERDC MSRC users to quickly & easily collect perfor–mance trace data & analyze that data visually to spot communication bottle–necks in their codes.
PAPI	Installed & tested on ERDC MSRC Cray T3E & SGI/Cray Origin2000, IBM implementation ready for installa–tion on SP & Power3	Provide a portable cross–platform interface to hardware performance counters	CHSSI code & other application developers who need access to hardware performance counter data	Tennessee	Enables users to use the same set of routines to access comparable performance data across platforms

Table 4
Tools Implemented

Tool	Status	Purpose	Users	Providing Institution	Impact
			SPPT		
dyninst	Package tested & available for Origin2000	To enable users to dynamically insert & remove instrumentation into & from a running application	Sophisticated users willing to learn a low–level but powerful interface for runtime application instrumentation	Univ. of Maryland Tennessee	Enables users to attach a running application & monitor or even change application behavior dynamically
UMD has produced the dyninst library which provides an API for attaching to an instrumenting an executable running on a single process. UTK has extended dyninst with support for parallel & distributed environments in the form of the Free Probe Class Server (FPCS). FPCS has been developed with DoE ASCI funding but is being made available on ERDC MSRC platforms as part of the ERDC–supported PAPI project.					
SCALAPACK	Available on all ERDC MSRC HPC platforms	Perform large scale linear algebra computations	Charles Manry (SPAWAR)	Tennessee	Ported Manry's DOD Challenge codes to this IBM machine
SuperLU	Built & installed on appropriate ERDC MSRC HPC platforms	Sparse, direct solver library	Tom Oppe ERDC MSRC CMG	NERSC LLNL	Available tool

Table 4
Tools Implemented

Tool	Status	Purpose	Users	Providing Institution	Impact
C/C					
Tango Interactive Version 2	Installed at ERDC MSRC, JSU, MSU, CAU	Distance education & training, remote collaboration	All interested in remote collaboration & training	Syracuse	Used to deliver academic credit classes to JSU, ERDC, & elsewhere; used to deliver one seminar & four distance trainings.
SV					
CbayVisGen	Installed	Visualization	Carl Cerco, others	NCSA/Illinois	Enables long–duration runs of CE–QUAL–IQM, including transport flux data
Tecplot Visualization Software	Installed at ERDC ITL Visualization Lab	Scientific Visualization Software	ERDC CHL & ITL scientists	Ohio State	Used for PET CWO pre–sentations & reports. Available to MSRC us-ers. It is a valuable tool for analyzing com– plex scientific data.

Table 5
ERDC MSRC User Codes Impacted

Code	Nature of Code	ERDC MSRC User(s)	Institutions Involved	Result
CFD				
OVERFLOW–D	Chimera Grid based CFD CHSSI code	Bob Meakin Jubraj Sahu and others	MSU	Code incorporated and validated. Perfomrance checked. Data storage optimization and visualization support.
FAST3D	Cartesian Grid based contaminant transport simulation system (CHSSI code)	Sandy Lanaburg Jay Bonj	MSU	Assistance in code porting on ERDC MSRC HPC platforms. Large scale data sites manipulation.
WIND	CFD Solver	Jerry Matty Ken Kennedy, Redstone Arsenal	MSU	Code incorporated and validated on ERDC MSRC machines. User support provided.

Table 5
ERDC MSRC User Codes Impacted

Code	Nature of Code	ERDC MSRC User(s)	Institutions Involved	Result
CSM				
CTH	CSM (penetration, impact & strong shock analysis)	Tommy Bevins (CSM impact, penetration, etc.)	UT Austin	Provide error indicators & adaptive capability in parallel CTH
EPIC	CSM (penetration, impact & analysis)	Mark Adley (CSM soil penetration, etc.)	UT Austin	Prototype local adaptive capability & error indicators added to ERIC
PAR3D	CSM (penetration, impact & analysis)	Robert Bernard (ERDC CHL)	MSU	Replaced difficult to maintain NASA software used in CHSSI code development with simpler locally maintained software. Helped CHSSI code developers to meet major milestone
GLS3D	CSM (penetration, impact & analysis)	Charlie Berger (ERDC CHL)	MSU	Replaced difficult to maintain NASA software used in CHSSI code development with simpler locally maintained software. Helped CHSSI code developers to meet major milestone
EPIC	CSM (penetration, impact & analysis)	Robert Stryk (Alliant Systems)	MSU	Preliminary parallelization of EPIC code provide starting point for Alliant Systems development activities

Table 5
ERDC MSRC User Codes Impacted

Code	Nature of Code	ERDC MSRC User(s)	Institutions Involved	Result
		CWO		
WAM	CWO wind–wave model	Robert Jensen	Ohio State	Coupled with CH3D–SED circulation/sediment model at the marine bottom boundary layer using the WCBL wave–current boundary layer model
CH3D–SED	CWO marine circulation & sediment transport model	Billy Johnson, Jeff Holland, Rao Vermulakouda	Ohio State	Coupled with WAM wave model at the marine bottom boundary layer using the WCBL wave–current boundary layer model
SWAN	CWO coastal wind–wave model	Robert Jensen, Lori Hadley	Ohio State	Deployed as finest nest of a 3–nest WAM Hurricane Luis simulation. Problems corrected in SWAN/WAM boundary condition interface. Results permitted comparison of SWAN & WAM wave predictions
MICOM	CWO marine circulation model	ERDC CHL coastal processes group	Ohio State Rice	Co–ordinated meetings to discuss development of a portable, parallel version of MICOM using the POSIX Threads software library

Table 5
ERDC MSRC User Codes Impacted

Code	Nature of Code	ERDC MSRC User(s)	Institutions Involved	Result
EQM				
CH3D–SIGMA	3D numerical hydrodynamic, salinity, & temperature model	Billy Johnson, Bob Bernard, Ron Heath	UT Austin	Runs in a dual–level parallel mode by using dynamic threading feature of OpenMP
MPOM	3D ocean circulation model	Le Ly (Navl Postgrad School) NAVO CWO users	UT Austin	MPOM is parallelized using MPI/OpenMP
TABS–MDS	Hydrodynamics simulator to produce velocities for water–quality studies	Charlie Berger, Gary Browne	UT Austin	Reduce mass–errors in TABS–MDS velocity fields for use in water–quality studies
CE–QUAL–ICM CE–QUAL–ICM/TOXI	Water quality simulators	Mark Dortch, Carl Cerco, Barry Bunch, Mark Noel	UT Austin	Message–passing in codes has been analyzed for inefficiencies, new message–passing protocols have been identified & will be implemented
CH3D–Z	Hydrodynamics simulator	Billy Johnson, Ron Heath	UT Austin	Replaced solution strategy for surface elevations & depth–integrate

Table 5
ERDC MSRC User Codes Impacted

Code	Nature of Code	ERDC MSRC User(s)	Institutions Involved	Result
FMS				
CMS	DIS M&S Comprehensive Mine Simulator	Ft. Belvoir	Syracuse	Parallel CMS on Origin2000, HLA compliance
ModSAF	DIS M&S	Ft. Belvoir	Syracuse	HLA compliance
Landscape Management System	EQM simulation	Jeff Holland, ERDC CHL	Syracuse	Distributed computing environment for coupled simulations with web–based front–end
SPP Tools				
CE–QUAL–ICM	EQM	EQM CTA	TICAM/UT Austin Tennessee	Discovered two aspects of code which needed improvement. Plan in use to improve scalability to solve the larger water quality problems efficiently
STWAVE	CWO	Jane Smith, Ann Sherlock	Rice	Convert to Fortran 95, optimize numerical algorithms & elementary function, outline parallelization using MPI

Table 5
ERDC MSRC User Codes Impacted

Code	Nature of Code	ERDC MSRC User(s)	Institutions Involved	Result
SPP Tools				
CH3D–SED	EQM	EQM CTA	Rice	Added OpenMP directives to the MPI version
Princeton Ocean Model	CWO	CWO CTA	Rice	Added OpenMP directives & developed an MPI version

Table 6
Technology Transfer

Technology	Source	Providing Institution	Purpose	MSRC Users	Impact
			CFD		
Dual–Level Parallel Algorithms using MPI and OpenMP	PET Technical Report presentations	MSU, Rice, NRC	To exploit next generation of HPC systems with distributed clusters of shared–memory processors	Zeki Demirbilek of ERDC	Any user who has an MPI code could potentially benefit by adding OpenMP parallelism as well, particularly those who are exploring a linear parameter space.
Enabling larger scale simulations	Parallel Programming Expertise, Technical Reports, Short courses	MSU, Rice, NRC	To assist MSRC users to choose an appropriate parallel programming model (e.g. MPI, HPF, OpenMP) when parallelizing their code	David Medina, AFRL Phillips Lab	Potentially all users of parallel MSRC computers. The MSRC will benefit if its machines are used in a more efficient way due to knowledgeable users.
Feature detection module	CFD team at MSU	MSU	To detect swirls in the large scale CFD data	CFD CTA	Visualization and interpretation of large scale CFD data sets.
Grid generation modules	Short course	MSU	To assist MSRC users in complex geometry grid problems	CFD CTA	Signficant reduction in turn around time

Table 6
Technology Transfer

Technology	Source	Providing Institution	Purpose	MSRC Users	Impact
CSM					
Block Adaptive Parallel CTH	IAT/UT & SNLA	UT Austin	To extend CTH capability to parallel adaptive simulation	Raju Namburu Kent Kimsey Dan Sheffler David Kleponis	Capability demonstrated release of code imminent, impact is very high
Local Adaptive EPIC	G. Johnson (Alliant Techsystems)	UT Austin	Extend EPIC for adaptive unstructured refinement with appropriate error indicators	Mark Adley Steve Akers Kirk Vanden (Eglin AFB)	Vehicle for indicator & mesh quality studies. First calculations of this type – impact potential is very high

Table 6
Technology Transfer

Technology	Source	Providing Institution	Purpose	MSRC Users	Impact
EQM					
Projection Algorithm	UT Austin	UT Austin	To project hydro–dynamics data onto water quality grid so as to conserve mass	Jeff Holland Charlie Berger Carl Cerco Barry Bunch Mark Dortch	Projection is essential for connecting hydro-dynamics codes to water quality models such as CE–QUAL–ICM. Otherwise, code will obtain incorrect results & may blow–up.
Discontinuous Galerkin Method	UT Austin	UT Austin	Potential method for discretizing flow & transport equations arising in EQM	Jeff Holland Charlie Berger Stacy Howington	This algorithm has potential for inclusion in the adaptive flow & transport code ADH being developed.
OpenMP	SGI	UT Austin	Improve load balance in the MPI processes	Rao Vermulakouda Ron Heath Billy Johnson	This dual–level parallelism technique improves load balance between MPI processes & improves CH3D–SIGMA code.
Vampir	Tennessee	UT Austin	Analyze message–massing & I/O performance of CE–QUAL–ICM & other EQM codes	Carl Cerco Barry Bunch Mark Noel	Improve scalability of all parallelized EQM codes.

Table 6
Technology Transfer

Technology	Source	Providing Institution	Purpose	MSRC Users	Impact
FMS					
WebHLA Infrastructure for Parallel CMS	Syracuse	Syracuse	Web infrastructure for parallel CMS was transferred to Ft. Belvoir in 1999. This major software release (60Meg) included the following modules developed at NPAC: JWORB OWRTI Parallel CMS JDIS SimVis Logger Federate Playback Federate	FMS CTA	This technology provides Web/ Commodity–based HLA compliant metacomputing infrastructure for Parallel CMS that will enable large scale minefield simulations of million mines that are of interest of the Night Vision Lab at Ft. Belvoir.

JWORB: Java–based CORBA broker integrated with the Web (HTTP & XML) server
OWRTI: Run–Time Infrastructure of HLA as Java–based JWORB facility
Parallel CMS: Origin 2000 port of CMS from Ft. Belvoir
JDIS: Java based DIS => HLA bridge server (for ModSAF subnet)
SimVis: In–house DirectX–based 3D simulation visualization front–end
Logger Federate: Used to have simulation events in a relational database
Playback Federate: Used to replay a simulation from an event database

Table 6
Technology Transfer

Technology	Source	Providing Institution	Purpose	MSRC Users	Impact
SPPT					
Debugging & Performance Analysis Tools	Various vendors & research groups	Tennessee	To provide tools for effective debugging & performance analysis of parallel applications	All	The SPPT Tools repository at www.nhse.org/rib/repositories/EREDC_ spp_tools/catalog provides an up–to–date listing of debugging & performance analysis tools available on ERDC MSRC platforms. A conside matrix view provides an at–a– glance summary of what tools are available on what platforms, as well as links to site– specific usage information & tutorials.
Access to Hardware Performance Counters	Various vendors	Tennessee	To provide a portable interface to hardware performance counters available on MSRC platforms	CHSSI code developers & other MSRC users who need access to this type of technology	The portable interface to hardware perfor– mance counters being developed by UTK will enable MSRC applica– tion developers to use the same set of routines to access comparable performance counter data across platforms.

Table 6
Technology Transfer

Technology	Source	Providing Institution	Purpose	MSRC Users	Impact
SPPT					
Memory Hierarchy Simulation	John Mellor–Crummey	Rice	Track cache & TLB misses & display the results with a Web browser	Potentially all CTAs	Model large application codes & reveal where cache misses is impacting perfor– mance. Follow this with possible changes to the source code to alleviate major problems
C/C					
WebFlow Distributed Computing Environment	Syracuse	Syracuse	Facilitate use of distributed HPC resource by applica–tions developers & users based on standard & commodity technologies	Jeff Holland Potentially all CTAs	Provides the ability to provide web–based user interfaces to HPC applications & to simplify application usage of HPC resources

Table 6
Technology Transfer

Technology	Source	Providing Institution	Purpose	MSRC Users	Impact
SV					
Transport Flux Visualization	NCSA/Illinois	NCSA/Illinois	Transport Flux Visualization	Carl Cerco	New Visualization capability

Table 7
Training Courses

Course Title	Location	Duration	Providing Institution	Instructor(s)	Format	Number of Attendees
Note: Attendees Broken Down By: (On–site MSRC users, Off–site MSRC users, PET/integrator personnel, HBCU/MI personnel, other)						
Using the Cray T3E	ERDC MSRC	2 Days	OSC	Troy Baer	Class, Tango	8 (0,2,6,0,0)
Parallelization, Optimization & Coupling of Marine Forecasting Models	ERDC MSRC	2 Days	Ohio State	David Welsh P. Sadayappan	Class	8 (6,0,2,0,0)
Mechanical Analysis using DADS	ERDC MSRC	4 Days	LMS CADSI	Dave Venum	Class	11 (10,1,0,0,0)
Ensight & EnSight Gold	ERDC MSRC	2 Days	CEI, Inc.	David Baumgartner Mel Spencer	Class	12 (4,4,3,1,0)
Designing & Building Parallel Programs	BBN New London, CT	4 Days	ERDC MSRC	Richard Weed Henry Gabb	Class	8 (0,8,0,0,0)
Multi–Threaded & Concurrent Programming with POSIX Threads	ERDC MSRC	2 Days	ERDC MSRC	Clay Breshears Henry Gabb	Class	9 (0,3,6,0,0)
HLA Special Training Event	ERDC MSRC	2 Days	DMSO	Nancy Malone Tony Lashley	Class	15 (8,0,7,0,0)
Distance Learning Workshop	JSU	2 Days	Syracuse	Mark Podgorney Nancy McCracken	Class, Tango	20 (0,2,4,23,0)

Table 7
Training Courses

Course Title	Location	Duration	Providing Institution	Instructor(s)	Format	Number of Attendees
Note: Attendees Broken Down By: (On–site MSRC users, Off–site MSRC users, PET/integrator personnel, HBCU/MI personnel, other)						
Parallel Linear Algebra Libraries	ERDC MSRC	2 Days	OSC	David Ennis	Class	5 (0,2,3,0,0)
Distance Training Workshop	ERDC MSRC	2 Days	Syracuse	Geoffrey Fox	Class	10 (1,0,9,0,0)
Parallel Algorithms	ERDC MSRC	2 Days	UT Austin	Mary Wheeler Clint Dawson Phu Luong C.T. Kelley	Class	10 (4,0,5,1,0)
Advanced EnSight	ERDC MSRC	2 Days	CEI, Inc.	Bruce Nay Mel Spencer	Class	7 (2,0,3,2,0)
IBM Power3 SMP Parallelization Workshop	ERDC MSRC	2 Days	IBM	Eric Myra	Class	12 (5,0,7,0,0)
Coupling Multiphysics Problems in Environmental Simulations	ERDC MSRC	2 Days	UT Austin Ohio State	Mary Wheeler Keith Bedford Phu Luong	Class	31 (13,7,8,1,2)
Grid Generation	ERDC MSRC	2 Days	UT Austin	Graham Carey	Class	12 (10,1,1,0,0)

Table 7
Training Courses

Course Title	Location	Duration	Providing Institution	Instructor(s)	Format	Number of Attendees
Note: Attendees Broken Down By: (On–site MSRC users, Off–site MSRC users, PET/integrator personnel, HBCU/MI personnel, other)						
AVS/Express	ERDC MSRC	4 Days	AVS, Inc.	Laura Webb	Class	5 (2,0,2,1,0)
Hierarchical Data Format (HDF5)	ERDC MSRC	2 Days	NCSA	Mike Folk	Class	11 (2,0,8,1,0)
Visualization Workshop	JSU	2 Days	JSU	Chuck Patrick	Class	12 (0,0,0,12,0)
Using the SGI Origin 2000	ERDC MSRC	2 Days	OSC	David Ennis	Class, Tango	8 (2,3,3,0,0)
Parallel Programming using OpenMP	ERDC MSRC	1 Day	OSC	David Ennis	Class, Tango	11 (5,2,4,0,0)
Hierarchical Data Format (HDF5)	ERDC MSRC	2 Days	NCSA	Mike Folk	Class	3 (0,1,0,2,0)

Table 8
Training Courses & Seminars at HBCU/MIs

Title	Location	Duration	Providing Institution	Instructor(s)	Format	Number of Attendees*
* Number of Attendees Broken Down by (Undergraduates, Graduate, Faculty/Staff)						
Fall 1999						
Topics in Networking & Multimedia Applications (graduate course)	JSU, Morgan State Clark Atlanta	16 Weeks	Syracuse	Roman Manoski	Web–Based Using Tango	19 (0,19,0)
Spring 2000						
Advanced Web Technologies (graduate course)	JSU, Morgan State Clark Atlanta	16 Weeks	Syracuse	Geoffrey Fox Nancy McCracken	Web–Based Using Tango	6 (0,6,0)
Programming for the Web (undergraduate course)	JSU	16 Weeks	JSU	Margues Griffin	Web–Based Class	19 (17,2,0)
Visualization Training	JSU	2 Days	JSU	Chuck Patrick	Scientific Visualization Class	18 (6,4,6)
Hands–On–CFD	Morgan State	1 Day	MSU	Bharat Soni	Hands–On–Class	
CFD	Clark Atlanta	1 Day	MSU	Bharat Soni	Class	

Table 9
HBCU/MI Students Impacted

Student	Level	Major	University	Impact
1999 Summer Institute				
Anoka, Natasha	Sophomore	Math	Howard	Summer Institute
Boudoin, Chanetta	Sophomore	Computer Science	Southern	Summer Institute
Bennett, Timia	Freshman	Computer Science	Langston	Summer Institute
Christian, Onekki	Sophomore	Computer Science	Jackson State	Summer Institute
Dafe, Oneki	Sophomore	Computer Science	Jackson State	Summer Institute
Grant, Valerie	Junior	Computer Science	Lincoln	Summer Institute
Gibson, Coray	Sophomore	Computer Science	Jackson State	Summer Institute
Gill, Kaizetta	Sophomore	Computer Science	Jackson State	Summer Institute
Johnson, Kimberly	Junior	Biology	Jackson State	Summer Institute
Lemons, Candace	Sophomore	Computer Science	Lincoln	Summer Institute
Moore, Qiana	Junior	Computer Science	Jackson State	Summer Institute
Reaves, Mary	Junior	Biochemistry	Tennessee	Summer Institute
Rider, Toure	Sophomore	Computer Science	Langston	Summer Institute
Silenok, Elena	Freshmen	Computer Science	Bethune–Cookman	Summer Institute

Table 9
HBCU/MI Students Impacted

Student	Level	Major	University	Impact
Sanders, Devin	Sophomore	Computer Science	Dillard	Summer Institute
Smith, Kendrick	Freshman	Computer Science	Jackson State	Summer Institute
Taylor, Marcus	Junior	Computer Science	Alcorn State	Summer Institute
Tiller, Tanisha	Junior	Computer Science	Lincoln	Summer Institute
Williams, Edwina	Sophomore	Computer Science	Dillard	Summer Institute
Fall 1999 Topics in Networking & Multimedia Applications				
Andavolu, Murthy	Graduate	Computer Science	Jackson State	Distance Learning
Budamgunta, Vansanthi	Graduate	Computer Science	Jackson State	Distance Learning
Deshpande, Vivek	Graduate	Computer Science	Jackson State	Distance Learning
Grant, Harriette C.	Graduate	Computer Science	Jackson State	Distance Learning
Iqbal, Jaweed	Graduate	Computer Science	Jackson State	Distance Learning
Jahagirdar, Shilpa	Graduate	Computer Science	Jackson State	Distance Learning
Li, Canhui	Graduate	Computer Science	Jackson State	Distance Learning
Mutyala, Sumankumar	Graduate	Computer Science	Jackson State	Distance Learning

Table 9
HBCU/MI Students Impacted

Student	Level	Major	University	Impact
Ningegowda, Pushpa	Graduate	Computer Science	Jackson State	Distance Learning
Patla, Venkatacharan	Graduate	Computer Science	Jackson State	Distance Learning
Rabarison, Monika	Graduate	Computer Science	Jackson State	Distance Learning
Rawls, Jennifer	Graduate	Computer Science	Jackson State	Distance Learning
Reddy, Anjani	Graduate	Computer Science	Jackson State	Distance Learning
Reddy, Pingill J.	Graduate	Computer Science	Jackson State	Distance Learning
Summers, Meland	Graduate	Computer Science	Jackson State	Distance Learning
Tang, Bingfeng	Graduate	Computer Science	Jackson State	Distance Learning
Uppu, Silva Prasad	Graduate	Computer Science	Jackson State	Distance Learning
Vivek, Ashodha	Graduate	Computer Science	Jackson State	Distance Learning
Yao, Gang	Graduate	Computer Science	Jackson State	Distance Learning

Table 9
HBCU/MI Students Impacted

Student	Level	Major	University	Impact
Fall 1999 Advanced Web Technologies				
Jackson, Wayne	Graduate	Computer Science	Jackson State	Distance Learning
Marpadga, Geetha	Graduate	Computer Science	Jackson State	Distance Learning
Mehta, Samir	Graduate	Computer Science	Jackson State	Distance Learning
Smith, Stacey	Graduate	Computer Science	Jackson State	Distance Learning
Summers, Meland	Graduate	Computer Science	Jackson State	Distance Learning
Yao, Gang	Graduate	Computer Science	Jackson State	Distance Learning
Spring 2000 Programming for the Web				
Bridges, Kristy D.	Undergrad	Computer Science	Jackson State	Distance Learning
Brooks, Lakeshia	Undergrad	Computer Science	Jackson State	Distance Learning
Carter, Andrea	Undergrad	Computer Science	Jackson State	Distance Learning
Crudup, Tamara	Undergrad	Computer Science	Jackson State	Distance Learning
Crutcher, Gwenson	Undergrad	Computer Science	Jackson State	Distance Learning
Dubey, Umesh K.	Graduate	Computer	Jackson State	Distance Learning
Gray, Katonya	Undergrad	Computer Science	Jackson State	Distance Learning

Table 9
HBCU/MI Students Impacted

Student	Level	Major	University	Impact
Horton, Irma	Undergrad	Computer Science	Jackson State	Distance Learning
Love, Lori L.	Undergrad	Computer Science	Jackson State	Distance Learning
Magee, Conswella	Undergrad	Computer Science	Jackson State	Distance Learning
Patrick, Ruth D.	Graduate	Computer Science	Jackson State	Distance Learning
Porter, Melonie C	Undergrad	Computer Science	Jackson State	Distance Learning
Price, Latoya T.	Undergrad	Computer Science	Jackson State	Distance Learning
Rayford, Lorraine	Undergrad	Computer Science	Jackson State	Distance Learning
Scott, Lisa M.	Undergrad	Computer Science	Jackson State	Distance Learning
Waterman, Chiquita	Undergrad	Computer Science	Jackson State	Distance Learning
Williams, Toboris B	Undergrad	Computer Science	Jackson State	Distance Learning
Wilson, Kendrick C.	Undergrad	Computer Science	Jackson State	Distance Learning
Wright, Melton S.	Undergrad	Computer Science	Jackson State	Distance Learning

Table 9
HBCU/MI Students Impacted

Student	Level	Major	University	Impact
Spring 2000 Visualization Training Workshop				
Anderson, Rondel	Graduate	Math	Jackson State	Visualization Training Workshop
Carter, Antoie	Undergrad	Computer Science	Jackson State	Visualization Training Workshop
Gates, Aisha	Undergrad	Computer Science	Jackson State	Visualization Training Workshop
Horton, Irma	Undergrad	Computer Science	Jackson State	VisualizationTraining Workshop
Jackson, Wayne	Graduate	Computer Science	Jackson State	VisualizationTraining Workshop
Matthews, Charles	Undergrad	Computer Science	Jackson State	Visualization Training Workshop
Mohamad, Abdul	Undergrad	Math	Jackson State	VisualizationTraining Workshop
Roundtree, Shayla	Undergrad	Computer Science	Jackson State	VisualizationTraining Workshop
Williams, Albert	Graduate	Computer Science	Jackson State	Visualization Training Workshop
Hughes, Ken	Undergrad	Computer Science	Jackson State	VisualizationTraining Workshop